UL 2790

STANDARD FOR SAFETY

Commercial Incinerators

UL Standard for Safety for Commercial Incinerators, UL 2790

First Edition, Dated November 8, 2010

Summary of Topics

This revision to ANSI/UL 2790 dated April 2, 2024 is being issued to update the title page to reflect the most recent designation as a Reaffirmed American National Standard (ANS). No technical changes have been made.

Text that has been changed in any manner or impacted by ULSE's electronic publishing system is marked with a vertical line in the margin.

The requirements are substantially in accordance with Proposal(s) on this subject dated February 16, 2024.

No Text on This Page

NOVEMBER 8, 2010
(Title Page Reprinted: April 2, 2024)

UL 2790

Standard for Commercial Incinerators

Prior to the first edition, the requirements for the products covered by this standard were included in the Outline of Investigation for Commercial Incinerators, SU 2790.

First Edition

November 8, 2010

This ANSI/UL Standard for Safety consists of the First Edition including revisions through April 2, 2024.

The most recent designation of ANSI/UL 2790 as a Reaffirmed American National Standard (ANS) occurred on April 2, 2024. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

Comments or proposals for revisions on any part of the Standard may be submitted to ULSE at any time. Proposals should be submitted via a Proposal Request in ULSE's Collaborative Standards Development System (CSDS) at https://csds.ul.com.

No Text on This Page

CONTENTS

INTRODUCTION

CONSTRUCTION – ELECTRICAL

CONSTRUCTION – MECHANICAL

CONSTRUCTION – INCINERATOR ASSEMBLY

CONSTRUCTION – BURNER ASSEMBLIES

PERFORMANCE

No Text on This Page

INTRODUCTION

1 Scope

1.1 These requirements apply to direct-fed incinerators, including those of the gas and electric ignition types, designed primarily for use as a crematory (as defined in 5.30). They are not intended to incinerate any hazardous, including biological/infectious, chemical and/or explosive, types of material and not intended for use in spaces in which flammable vapor or gases may be present.

1.2 These requirements are only intended to cover the safety aspect of the direct-fed incinerators, with respect to fire, shock, mechanical hazards, and carbon monoxide emissions.

1.3 Crematories covered by these requirements are the factory-made type and may be field assembled. These requirements do not cover an incinerator that requires the use of a brick or masonry wall, etc., which forms a part of the building structure.

1.4 Gas-heating incinerators covered by these requirements may be operated without a competent attendant being constantly on duty at the burners while the burners are in operation.

1.5 Incinerators may be subject to local regulations and/or EPA regulations, such as the Clean Air Act and/or the Resource Conservation and Recovery Act, with respect to:

a) Particulate emissions, oxides of nitrogen, and other products of combustion in the flue gas. These requirements do not include limitations on Nox emissions and only carbon monoxide was required to be within the specified limits.

b) The types of wastes to be incinerated.

1.6 Additional installation and operation requirements are available as defined by the National Fuel Gas Code, NFPA 54, the Liquefied Petroleum Gas Code, NFPA 58, the National Electrical Code, NFPA 70 and other codes as applicable.

2 Components

2.1 Except as indicated in 2.2, a component of a product covered by this Standard shall comply with the requirements for that component.

2.2 A component need not comply with a specific requirement that:

a) Involves a feature or characteristic not needed in the application of the component in the product covered by this Standard, or

b) Is superseded by a requirement in this Standard.

2.3 A component shall be used in accordance with its rating established for the intended conditions of use.

2.4 Specific components are incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions.

3 Units of Measurement

3.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

3.2 Unless indicated otherwise, all voltage and current values mentioned in this standard are rms.

4 Undated References

4.1 Any undated reference to a code or standard appearing in the requirements of this Standard shall be interpreted as referring to the latest edition of that code or standard.

5 Glossary

5.1 For the purposes of this Standard the following definitions apply.

5.2 AIR SHUTTER – An adjustable device for varying the size of the air inlet or inlets regulating primary or secondary air.

5.3 AIR SHUTTER, AUTOMATICALLY OPERATED – An air shutter operated by an automatic control.

5.4 AIR SHUTTER, MANUALLY OPERATED – An air shutter manually set and locked in the desired position.

5.5 ALUMINUM COATED STEEL – An aluminum coated steel in which the bond between the steel and the aluminum is an iron-aluminum alloy.

5.6 ASH – The solid residue remaining after combustion or incineration has been completed.

5.7 ASH PIT DOOR – A door below the grate level used for removing ash or other noncombustibles from the incinerator.

5.8 BAFFLE – An object placed in an incinerator to direct the flow of air or flue gases.

5.9 BASE – The main supporting frame or structure of the assembly.

5.10 BURNER – A device for the final conveyance of the gas, or a mixture of gas and air, to the combustion zone.

5.11 BURNER, AUTOMATICALLY LIGHTED – One where fuel to the main burner is normally turned on and ignited automatically.

5.12 BURNER, MANUALLY LIGHTED – One where fuel to the main burner is turned on only by hand and ignited under supervision.

5.13 BURNER HEAD, GAS – That portion of a burner beyond the outlet end of the mixer tube which contains the ports.

5.14 CASING – An enclosure forming the outside of the incinerator, no parts of which are likely to be subjected to intense heat.

5.15 CHIMNEY, HIGH-HEAT – A chimney capable of withstanding a continuous flue gas temperature exceeding 982°C (1800°F).

5.16 CHIMNEY, MEDIUM-HEAT – A chimney capable of withstanding a continuous flue gas temperature not exceeding 982°C (1800°F).

5.17 CHIMNEY CONNECTOR – The pipe which connects a fuel burning incinerator to a chimney.

5.18 CHIMNEY, FACTORY BUILT – Those chimneys of the factory-made type intended for use with gas fired incinerators.

5.19 COMBUSTIBLE MATERIAL – Combustible material, as pertaining to materials adjacent to or in contact with heat producing incinerators, chimney connectors and vent connectors, means material made of or surfaced with wood, compressed paper, plant fibers, or other material that will ignite and burn. Such material shall be considered as combustible even though flameproofed, fire retardant treated, or plastered.

5.20 COMBUSTION – As used herein, the rapid oxidation of fuel accompanied by the production of heat, or heat and light. Complete combustion of a fuel is possible only in the presence of an adequate supply of oxygen.

5.21 COMBUSTION CHAMBER – The portion of an incinerator within which combustion occurs.

5.22 COMBUSTION DETECTOR – That part of a primary safety control which is responsive directly to flame properties.

5.23 COMBUSTION PRODUCTS – Constituents resulting from the combustion of a fuel with the oxygen of the air, including the inerts, but excluding excess air.

5.24 CONTROL – A device designed to regulate the fuel, air, or electrical supply to the controlled incinerators. It may be automatic, semi-automatic, or manual.

5.25 CONTROL INPUT, COMBUSTION – A control which automatically regulates the firing rate at predetermined air-fuel ratio in accordance with load demand. It may be a type which positions the air and fuel supplies for low fire and for high fire as required to meet the load demands, or it may be a modulating type which gradually varies the air and fuel supplies within limits to meet the load demand.

5.26 CONTROL, LIMIT – A safety (protective) control that is responsive to changes in pressure, temperature or flow. This control may be used for regulating purposes or may be set beyond the intended operating range of the controlled equipment to limit its operation. This control may be electrical or mechanical in nature.

5.27 CONTROL, OPERATING – A control to start or regulate burner firing according to load demand and to stop or regulate firing of the burner on satisfaction of demand or upon reaching normal temperature or pressure in the incinerator being fired. An operating control may be electrical or mechanical in nature and may actuate auxiliary devices to perform the functions described above. An operating control could provide Type 1 or Type 2 action. (See 5.76 and 5.77.)

5.28 CONTROL, SAFETY (PROTECTIVE) – A control intended to prevent the risk of electric shock, fire, or injury to persons during abnormal operation of the appliance. An example would be a high gas pressure limit control. A protective control always provides Type 2 action. (See 5.76 and 5.77.)

5.29 CONTROL, PRIMARY SAFETY – An automatic control that monitors the operation of a gas-fired or an oil-fired burner. It normally consists of the following sections that may be integrated into a common unit or may be separate units, interconnected by wiring:

a) Programming Unit – A device that programs the burner through start-up and shutdown operations in response to signals from regulating, limiting, and monitoring devices. It also provides the timings, as required, in proper sequence, for purging, flame establishing periods and in case of ignition or flame failure, for safety shutdown (lockout).

b) Combustion Detector – A device that is responsive to flame properties. It monitors the flame at the point of flame supervision and transmits a signal to the programming unit, indicating absence or presence of flame.

5.30 CREMATORY – An incinerator, for commercial purposes, used to reduce to ash animal and human cadavers. It is intended to be factory-made and can be installed as a packaged unit or assembled in the field from factory built subassemblies.

5.31 ELECTRICAL CIRCUITS:

a) High-Voltage Circuit – A circuit involving a potential of not more than 600 volts and having circuit characteristics in excess of those of a low-voltage circuit.

b) Low-Voltage Circuit – A circuit involving a potential of not more than 30 volts alternating current (42.4 peak) or direct current and supplied by a primary battery or by a standard Class 2 transformer or other suitable transforming device, or by a suitable combination of transformer and fixed impedance having output characteristics in compliance with what is required for a Class 2 transformer. A circuit derived from a source of supply classified as a high-voltage circuit, by connecting resistance in series with the supply circuit as a means of limiting the voltage and current, is not considered to be a low-voltage circuit.

c) Isolated Limited Secondary Circuit – A circuit of limited energy derived from an isolated secondary winding of a transformer having a maximum capacity of 100 volt-amperes (VA) and open-circuit secondary voltage rating not exceeding 1000 volts.

d) Safety Control Circuit – A circuit involving one or more safety controls in which failure due to grounding, opening, or shorting of any part of the circuit can cause unsafe operation of the controlled incinerator or can introduce a direct fire or life hazard.

5.32 EXCESS AIR – Air which passes through the combustion chamber and the incinerator flues in excess of that which is theoretically required for complete combustion.

5.33 FLAME SAFEGUARD – See Control, Primary Safety, 5.29.

5.34 FLUE – A conduit or passageway, vertical or nearly so, for conveying flue gases to the outer air.

5.35 FLUE COLLAR – That portion of an incinerator designed for attachment of the chimney, flue or vent connector.

5.36 FLUE GASES – Combustion products and excess air.

5.37 FLUE PIPE – The conduit connecting the incinerator with the chimney.

5.38 GAS VENT – The piping and fittings for conveying flue gases to the outside atmosphere.

5.39 HEATING SURFACES – All surfaces which transmit heat directly from flame or flue gases to the medium to be heated.

5.40 IGNITION, CONTINUOUS – Ignition by an energy source which is continuously maintained through the time the burner is in service, whether the main burner is firing or not.

5.41 IGNITION, INTERMITTENT – Ignition by an energy source which is continuously maintained through the time the burner is firing.

5.42 IGNITION, INTERRUPTED – Ignition by an energy source which is automatically energized each time the main burner is fired and subsequently is automatically shut off during the firing cycle.

5.43 INTERLOCK – A control to prove the physical state of a required condition, and to furnish that proof to the primary safety control circuit.

5.44 LINER – See Radiation Shield, 5.69.

5.45 LINING – Those interior surfaces of a combustion chamber which are exposed to combustion during use of the incinerator.

5.46 LIQUEFIED-PETROLEUM GAS – Fuel gases, including commercial propane, predominantly propane or propylene or commercial butane, predominantly butane, isobutane, and/or butylene.

5.47 LP-GAS AIR MIXTURE – Liquefied-petroleum gases distributed at relatively low pressures and normal atmospheric temperatures which have been diluted with air to produce desired heating value and utilization characteristic.

5.48 MAIN BURNER FLAME-ESTABLISHING PERIOD – The interval of time the main burner fuel safety shutoff valves are permitted to be open before the primary safety control is required to supervise the main burner flame.

5.49 MANIFOLD – The conduit of an incinerator which supplies gas to the individual burner.

5.50 MIXER, GAS – The combination of mixer head, mixer throat, and mixer tube.

a) Mixer Head – That portion of an injection type burner, usually enlarged, into which primary air flows to mix with the gas stream.

b) Mixer Throat – That portion of the mixer which has the smallest cross-sectional area and which lies between the mixer head and the mixer tube.

c) Mixer Tube – That portion of the mixer which lies between the throat and the burner head.

5.51 MIXER FACE, GAS – The air inlet end of the mixer head.

5.52 NORMAL CARE – The periodic tasks usually performed to operate and maintain an incinerator, such as air, fuel, pressure, and temperature regulation, cleaning, lubrication, and resetting of controls.

5.53 ORIFICE – The opening in a cap, spud, or other device whereby the flow of gas is limited and through which the gas is discharged to a burner.

5.54 ORIFICE CAP (HOOD) – A movable fitting having an orifice which permits adjustment of the flow of gas by the changing of its position with respect to a fixed needle or other device.

5.55 ORIFICE SPUD – A removable plug or cap containing an orifice and which permits adjustment of the flow of gas either by substitution of a spud with a different sized orifice or by the motion of a needle with respect to it.

5.56 PILOT – A small flame which is utilized to ignite the fuel at the main burner or burners.

5.57 PILOT, AUTOMATIC – Consists of an automatic pilot device and pilot burner assembly securely assembled in fixed functional relationship.

5.58 PILOT, CONTINUOUS – A pilot that burns without turn-down throughout the entire time the burner assembly is in service, whether the main burner is firing or not.

5.59 PILOT, EXPANDING – A pilot that burns throughout the entire time the burner assembly is in service, whether the main burner is firing or not. Upon a call for heat, the pilot is automatically expanded so as to reliably ignite the main burner. This pilot may be turned down automatically at the end of main burner flame-establishing period.

5.60 PILOT FLAME-ESTABLISHING PERIOD – The interval of time fuel is permitted to be delivered to a proved pilot before the primary safety control is required to detect pilot flame.

5.61 PILOT, INTERMITTENT – A pilot which is automatically lighted each time there is a call for heat, if burns during the entire period that the main burner is firing.

5.62 PILOT, INTERRUPTED – A pilot which is automatically lighted each time there is a call for heat. The pilot fuel is cut off automatically at the end of the main burner flame-establishing period.

5.63 PILOT, PROVED – A pilot flame supervised by a primary safety control.

5.64 PORT – Any opening in a burner head through which fuel or an air-fuel mixture is discharged for ignition.

5.65 PRIMARY AIR – The air introduced into a burner which mixes with the fuel before it reaches the ignition zone.

5.66 POST-PURGE PERIOD – The period of time after the fuel delivered to the burner is stopped and during which the burner motor or fan continues to run to supply air to the combustion chamber.

5.67 PREPURGE PERIOD – The period of time during the burner start-up in which air is introduced into the combustion chamber and the associated flue passages in such volume and manner as to completely replace the air or fuel-air mixture contained therein prior to initiating ignition.

5.68 PROOF OF CLOSURE SWITCH – A non-field adjustable switch installed in a safety shutoff valve by its manufacturer that activates only after the valve is fully closed.

5.69 RADIATION SHIELD – A separate panel or panels interposed between heating surfaces and adjacent objects to reduce heat transmission by radiation.

5.70 READILY ACCESSIBLE – Capable of being reached easily and quickly for operation, adjustment, and inspection.

5.71 REGULATOR, GAS-PRESSURE – A device for controlling and maintaining a uniform outlet gas pressure.

5.72 RESPONSE TIME – FLAME FAILURE – The interval between the occurrence of flame extinguishment and de-energizing the safety shutoff means.

5.73 SAFETY CONTROL – See Control, Safety, 5.28.

5.74 SAFETY SHUTDOWN – The action of shutting off all fuel and ignition energy to the incinerator by means of a safety control or controls such that restart cannot be accomplished without manual reset.

5.75 SECONDARY AIR – The air externally supplied to the flame at the point of combustion.

5.76 THERMOSTAT – An automatic control actuated by temperature change to maintain temperatures between predetermined limits.

5.77 TOOLS, SPECIAL – Those tools that are not available on the open retail market.

5.78 TYPE 1 ACTION – Automatic action for which the manufacturing deviation and the drift of its operating value, operating time, or operating sequence have not been declared and tested to the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1.

5.79 TYPE 2 ACTION – Automatic action for which the manufacturing deviation and the drift of its operating value, operating time, or operating sequence have been declared and tested to the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1.

5.80 VALVE, BURNER-INPUT CONTROL – An automatic-control valve for regulating the input of fuel to a burner.

5.81 VALVE, SAFETY SHUTOFF – A valve that is automatically closed by the safety control system or by an emergency device. Such valve may be of the automatic or manually opened type.

5.82 VALVE, LUBRICATED PLUG TYPE – A valve of the plug and barrel type designed for maintaining a lubricant between the bearing surfaces.

5.83 VALVE, MANUAL GAS SHUTOFF – A manually operated valve in a gas line for the purpose of completely turning on or shutting off the gas supply.

5.84 VENT CONNECTOR – The pipe which connects a gas-fired incinerator to a gas vent or chimney.

5.85 ZERO GOVERNOR – A regulating device which is normally adjusted to deliver gas at atmospheric pressure within its flow rating.

CONSTRUCTION – ELECTRICAL

6 General

6.1 Electrical devices and wiring shall be arranged so that oil or water will not drip or run on them during normal usage or from a connection required to be uncoupled for servicing the incinerator.

6.2 Attachment plugs or separable connectors shall not be used in circuits when the breaking or making of the circuit by such devices may result in operation of the incinerator in a manner that involves a risk of fire, electric shock, or injury to persons.

7 Servicing and Adjustment

7.1 Service functions which may have to be performed with the incinerator energized include:

a) Adjusting the setting of temperature controls with or without marked dial settings;

b) Resetting control trip mechanism; operating manual switches;

c) Adjusting air-flow dampers.

A factory set and sealed control is not considered to be adjustable.

7.2 Adjustable or resettable electrical control or manual switching devices may be located or oriented with respect to uninsulated live parts so that manipulation of the mechanism for adjustment, resetting, or operation can be accomplished in the normal direction of access if uninsulated live parts or moving parts are:

a) Not located in front, in the direction of access of the mechanism; and

b) Are not located within 6 inches (152 mm) on any side or behind the mechanism, unless guarded.

7.3 An electrical control component which may require examination, adjustment, servicing, or maintenance while energized, not including voltage measurements, shall be located and mounted with respect to other components and with respect to grounded metal parts so that it is accessible for electrical service functions without subjecting the serviceman to the likelihood of risk of electric shock from adjacent uninsulated live parts or to the risk of injury from adjacent moving parts.

7.4 Components in a low-voltage circuit are to comply with the requirements of 21.3 in their relation to uninsulated live parts in a high-voltage circuit and to moving parts.

8 Enclosures

8.1 General

8.1.1 Uninsulated live high-voltage parts shall be enclosed or guarded to prevent unintentional contact by persons during normal use of the appliance. This applies to such parts located in a compartment where access is required for normal care of the appliance, such as resetting controls, replacing filters, lubrication, cleaning, and the like.

8.1.2 Among the factors taken into consideration when judging the acceptability of an enclosure are:

a) Mechanical strength;

b) Resistance to impact;

c) Moisture-absorptive properties;

d) Combustibility;

e) Resistance to corrosion; and

f) Resistance to distortion at temperatures to which the enclosure may be subjected under conditions of normal or abnormal use.

For a nonmetallic enclosure or part of an enclosure, all these factors are considered with respect to thermal and chemical aging according to the requirements in the Standard for Polymeric Material – Use in Electrical Equipment Evaluations, UL 746C.

8.1.3 The enclosure shall reduce the likelihood of the emission of molten metal, burning insulation, flaming particles, or the like through openings onto combustible material, including the surface on which the equipment is mounted.

8.1.4 Where the design and location of the component and the strength and rigidity of the outer cabinet warrant, an individual enclosure of thinner metal than specified in Table 8.1 or Table 8.2 whichever applies, may be employed.

8.1.5 Electrical parts within the outer cabinet need not be individually enclosed if the assembly conforms with all of the following:

a) Their design and location with respect to openings in the outer cabinet will not result in the emission of flame or molten metal through openings in the cabinet or if it can be shown that failure of the component would not result in a risk of fire;

b) There are no openings in the bottom of the compartment in which the part is located which would permit dropping of molten metal, and the like, onto combustible material;

c) The part is not in proximity to combustible material other than electrical insulation;

d) The part is not located closer than 5 inches (127 mm) to the outer cabinet unless the thickness of sheet metal is in compliance with Table 8.1;

e) The part is not located in an air-handling compartment;

f) The thickness of the outer cabinet is not less than two-gage thicknesses thinner than indicated in Table 8.1 for the maximum dimensions of the cabinet enclosure.

g) The part is not subject to unintentional contact by persons. See 22.8 – 22.17.

8.1.6 The requirements of 8.1.5 apply only to parts of high-voltage circuits as defined by these requirements.

8.1.7 All intended mounting positions of the unit are to be considered when determining if it complies with the requirement of 8.1.3.

8.1.8 Cabinet compartments housing gas piping and controls shall be ventilated.

8.1.9 Steel enclosures shall be protected against corrosion by painting, plating, or equivalent means.

8.1.10 The thickness of a sheet metal enclosure shall be as indicated in Table 8.1 and Table 8.2.

Exception: When the design and location of components and the strength and rigidity of the outer cabinet warrant, an individual enclosure thinner than specified in Table 8.1 and Table 8.2 is able to be employed.

Table 8.1
Minimum thickness of sheet metal for enclosures – carbon steel or stainless steel

Without supporting frame[a]				With supporting frame or equivalent reinforcing				Minimum thickness, inches (mm)			
Maximum width[b]		Maximum length[c]		Maximum width[b]		Maximum length		Uncoated (MSG)		Metal coated (GSG)	
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)				
4.0	(10.2)	Not limited		6.25	(15.9)	Not limited		0.020	(0.51)	0.023	(0.58)
4.75	(12.1)	5.75	(14.6)	6.75	(17.1)	8.25	(21.0)	(24)		(24)	
6.0	(15.2)	Not limited		9.5	(24.1)	Not limited		0.026	(0.66)	0.029	(0.74)
7.0	(17.8)	8.75	(22.2)	10.0	(25.4)	12.5	(31.8)	(22)		(22)	
8.0	(20.4)	Not limited		12.0	(30.5)	Not limited		0.32	(0.81)	0.034	(0.86)
9.0	(22.9)	11.5	(29.2)	13.0	(33.0)	16.0	(40.6)	(20)		(20)	
12.5	(31.8)	Not limited		19.5	(49.5)	Not limited		0.042	(1.07)	0.045	(1.14)
14.0	(35.6)	18.0	(45.7)	21.0	(53.3)	25.0	(63.5)	(18)		(18)	
18.0	(45.7)	Not limited		33.0	(83.8)	Not limited		0.060	(1.53)	0.063	(1.61)
25.0	(63.5)	31.0	(78.7)	35.0	(89.0)	43.0	(109.2)	(15)		(15)	
25.0	(63.4)	Not limited		39.0	(99.1)	Not limited		0.067	(1.70)	0.070	(1.78)
29.0	(73.7)	36.0	(91.4)	41.0	(104.0)	51.0	(129.5)	(14)		(14)	
33.0	(83.8)	Not limited		51.0	(129.5)	Not limited		0.080	(2.04)	0.084	(2.13)
35.0	(89.0)	47.0	(119.4)	54.0	(137.1)	66.0	(167.6)	(13)		(13)	
42.0	(106.7)	Not limited		64.0	(162.6)	Not limited		0.093	(2.36)	0.097	(2.46)
42.0	(119.4)	59.0	(149.9)	68.0	(172.7)	84.0	(213.4)	(12)		(12)	
52.0	(135.1)	Not limited		80.0	(203.2)	Not limited		0.108	(2.74)	0.111	(2.80)
60.0	(152.4)	74.0	(188.0)	84.0	(213.4)	103.0	(261.6)	(11)		(11)	
63.0	(160.0)	Not limited		97.0	(246.4)	Not limited		0.123	(3.12)	0.126	(3.20)
73.0	(185.4)	90.0	(228.6)	103.0	(261.6)	127.0	(322.6)	(10)		(10)	

[a] A supporting frame is a structure of angle or channel or a folded rigid section of sheet metal which is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and which has sufficient torsional rigidity to resist the bending moments which may be applied via the enclosure surface when it is deflected. Construction that is considered to have equivalent reinforcing may be accomplished by designs that will produce a structure which is a rigid as one built with a frame of angles or channels. Construction considered to be without supporting frame includes:

1) single sheet with single formed flanges (formed edges),

2) a single sheet which is corrugated or ribbed, and

3) an enclosure surface loosely attached to a frame, for example, with spring clips.

[b] The width is the smaller dimension of a rectangular sheet metal piece which is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.

[c] For panels which are not supported along one side, e.g., side panels of boxes, the length of the unsupported side shall be lifted to the dimensions specified unless the side in question is provided with a flange at lease 1/2 inch (12.7 mm) wide.

Table 8.2
Minimum thickness of sheet metal for enclosures – aluminum, copper, or brass

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness	
Maximum width[b]		Maximum length[c]		Maximum width[b]		Maximum length			
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	(mm)	(AWG)
3.0	(7.6)	Not limited		7.0	(17.8)	Not limited		0.023	(0.58)
3.5	(8.9)	4.0	(10.2)	8.5	(21.6)	9.5	(24.1)		(22)
4.0	(10.2)	Not limited		10.0	(25.4)	Not limited		0.029	(0.74)
5.0	(12.7)	6.0	(15.2)	10.5	(26.7)	13.5	(34.3)		(20)
6.0	(15.2)	Not limited		14.0	(35.6)	Not limited		0.036	(0.91)
6.5	(16.5)	8.0	(20.3)	15.0	(38.1)	18.0	(45.7)		(18)
8.0	(20.3)	Not limited		19.0	(48.3)	Not limited		0.045	(1.14)
9.5	(24.1)	11.5	(29.2)	21.0	(53.3)	25.0	(63.5)		(16)
12.0	(30.5)	Not limited		28.0	(71.1)	Not limited		0.058	(1.47)
14.0	(35.6)	16.0	(40.6)	30.0	(76.2)	37.0	(94.0)		(14)
18.0	(45.7)	Not limited		42.0	(106.7)	Not limited		0.075	(1.91)
20.0	(50.8)	25.0	(63.4)	45.0	(114.3)	55.0	(139.7)		(12)
25.0	(63.4)	Not limited		60.0	(152.4)	Not limited		0.095	(2.41)
29.0	(73.7)	36.0	(91.4)	64.0	(162.6)	78.0	(198.1)		(10)
37.0	(94.0)	Not limited		87.0	(221.0)	Not limited		0.122	(3.10)
42.0	(106.7)	53.0	(134.6)	93.0	(236.2)	114.0	(289.6)		(8)
52.0	(132.1)	Not limited		123.0	(312.4)	Not limited		0.153	(3.89)
60.0	(152.4)	74.0	(188.0)	130.0	(330.2)	160.0	(406.4)		(6)

[a] A supporting frame is a structure of angle or channel or a folded rigid section of sheet metal which is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and which has sufficient torsional rigidity to resist the bending moments which may be applied via the enclosure surface when it is deflected. Construction that is considered to have equivalent reinforcing may be accomplished by designs that will produce a structure which is as rigid as one built with a frame of angles or channels. Construction considered to be without supporting frame includes:

1) single sheet with single formed flanges (formed edges),

2) a single sheet which is corrugated or ribbed, and

3) an enclosure surface loosely attached to a frame, such as, with spring clips.

[b] The width is the smaller dimension of a rectangular sheet metal piece which is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.

[c] For panels which are not supported along one side, for example, side panels of boxes, the length of the unsupported side shall be limited to the dimensions specified unless the side in question is provided with a flange at lease 1/2 inch (12.7 mm) wide.

8.1.11 Sheet metal to which a wiring system is to be connected in the field shall have a thickness not less than 0.032 inch (0.81 mm) (No. 20 MSG) if uncoated steel, not less than 0.034 inch (0.86 mm) (No. 20 GSG) if galvanized steel, and not less than 0.045 inch (1.14 mm) if nonferrous.

8.1.12 If insulating material other than electrical insulation is provided within the enclosure, consideration is given to the burning characteristics and combustibility of the material and the proximity of an ignition source.

8.1.13 Terminal housings of motors, to which connections are to be made in the field, shall be of metal and shall be sized in accordance with the National Electrical Code, NFPA 70.

8.1.14 A junction box partially formed by another part such as a fan scroll or a motor casing is to fit such that:

a) An opening between the box and motor frame having a dimension exceeding 1/2 inch (12.7 mm) does not permit a flat feeler gauge, 5/64 by 1/2 inch (2.0 by 12.7 mm) wide to enter; and

b) An opening between the box and motor frame having no dimension exceeding 1/2 inch (12.7 mm) does not permit the entrance of a 13/64 inch (5.2 mm) diameter rod.

8.1.15 The criteria for judging an opening in an electrical enclosure are given in the following items and the related figures:

a) An opening that will not permit entrance of a 3/4 inch (19.1 mm) diameter rod is acceptable if:

1) A probe, as illustrated in Figure 8.1, cannot be made to touch any uninsulated live part when inserted through the opening; and

2) A probe, as illustrated in Figure 8.1, cannot be made to touch enamel insulated wire when inserted through the opening.

b) An opening that will permit entrance of a 3/4 inch diameter rod is acceptable under the conditions described in Doors and covers, 8.3.

8.1.16 During the examination for conformance with the requirements in 8.1.15, a part of the enclosure, which may be removed with the use of tools is to be removed.

8.2 Accessibility of uninsulated live parts and film-coated wire – general

8.2.1 During the examination of a product to determine whether it complies with the requirements concerning accessibility of uninsulated live parts and film-coated wire:

a) A part of the enclosure that may be opened or removed by the user without using a tool, (to attach an accessory, to make an operating adjustment, or for other reasons) is to be opened or removed;

b) Insulated brush caps are not required to be additionally enclosed;

c) The probes shall be applied to any depth that the opening will permit; and shall be rotated or angled before, during, and after insertion through the opening to any position that is necessary to examine the enclosure; and

d) The probes shall be used as measuring instruments to judge the accessibility provided by an opening, and not as instruments to judge the strength of a material; they shall be applied with the minimum force necessary to determine accessibility.

8.2.2 The criteria for judging an opening in an electrical enclosure are given in (a) – (b) and the related figures:

a) An opening that will not permit entrance of a 3/4 inch (19.1 mm) diameter rod is acceptable if:

1) A probe as illustrated in Figure 8.1 cannot be made to touch any uninsulated live part when inserted through the opening; and

2) A probe as illustrated in Figure 8.2 cannot be made to touch film-coated wire when inserted through the opening.

b) An opening that will permit entrance of a 3/4 inch (19.1 mm) diameter rod is acceptable under the conditions described in Doors and covers, 8.3.

Figure 8.1

Probe for uninsulated live metal parts

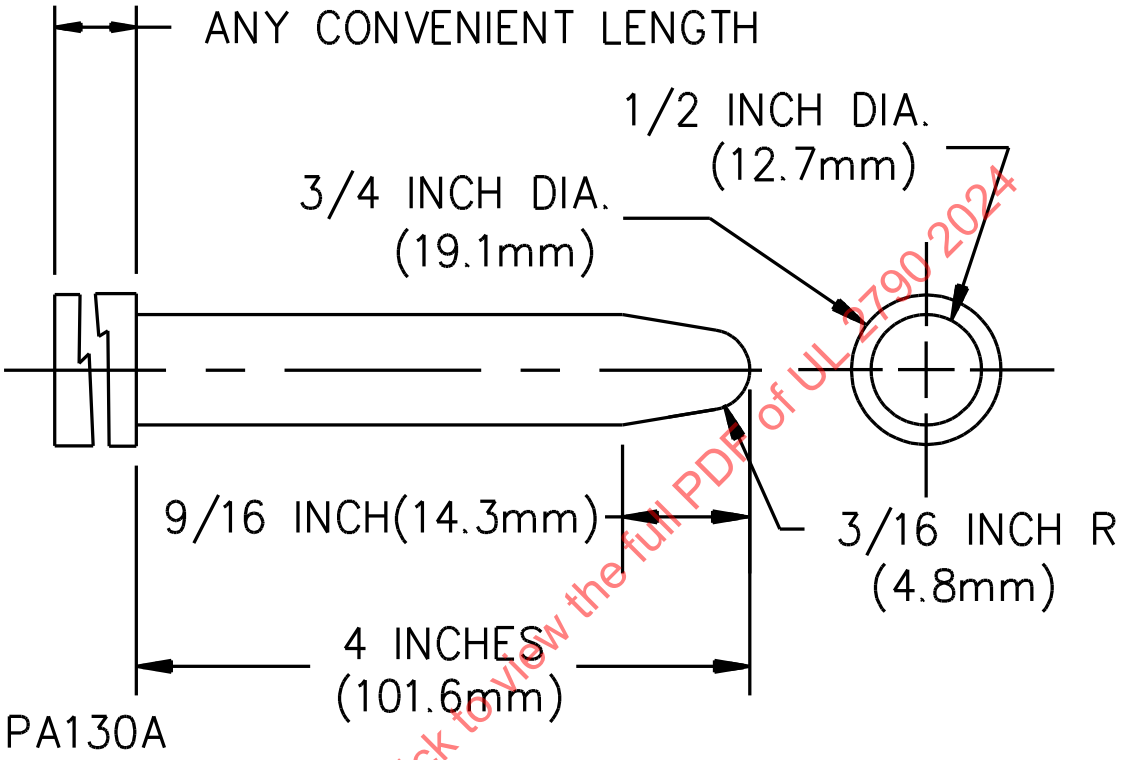


Figure 8.2

Probe for film-coated wire

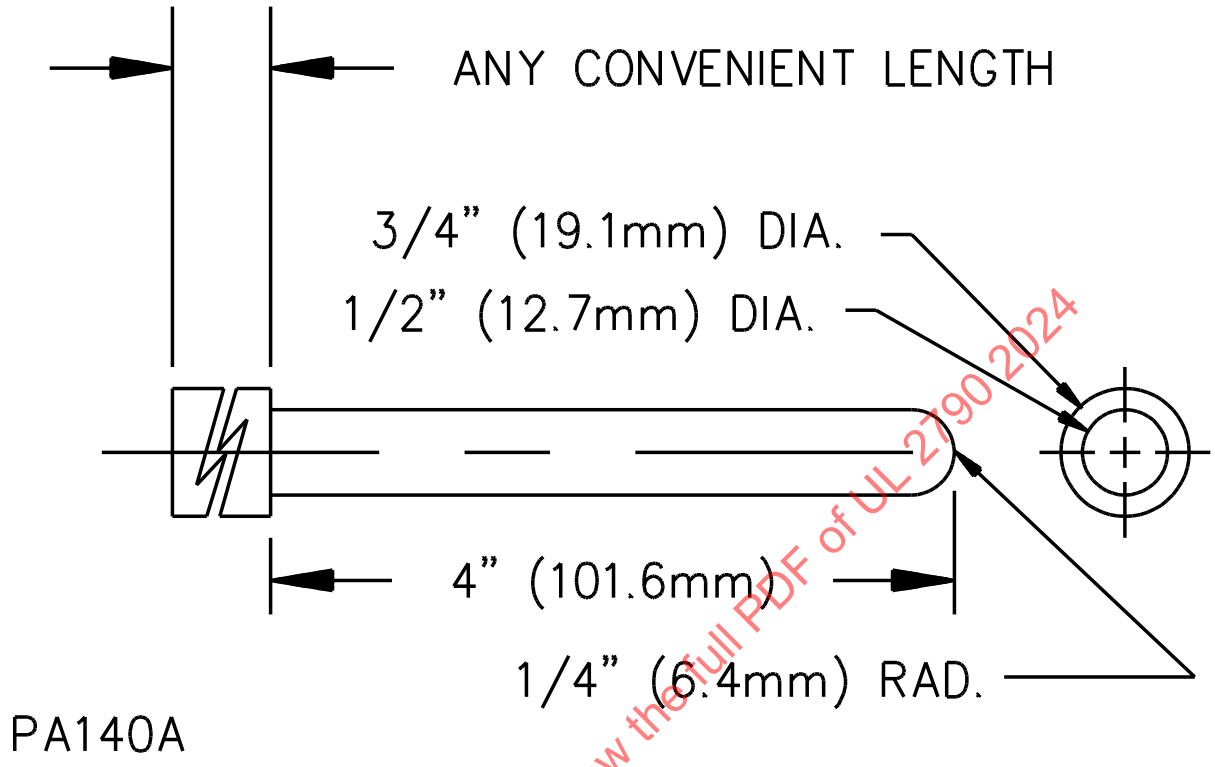
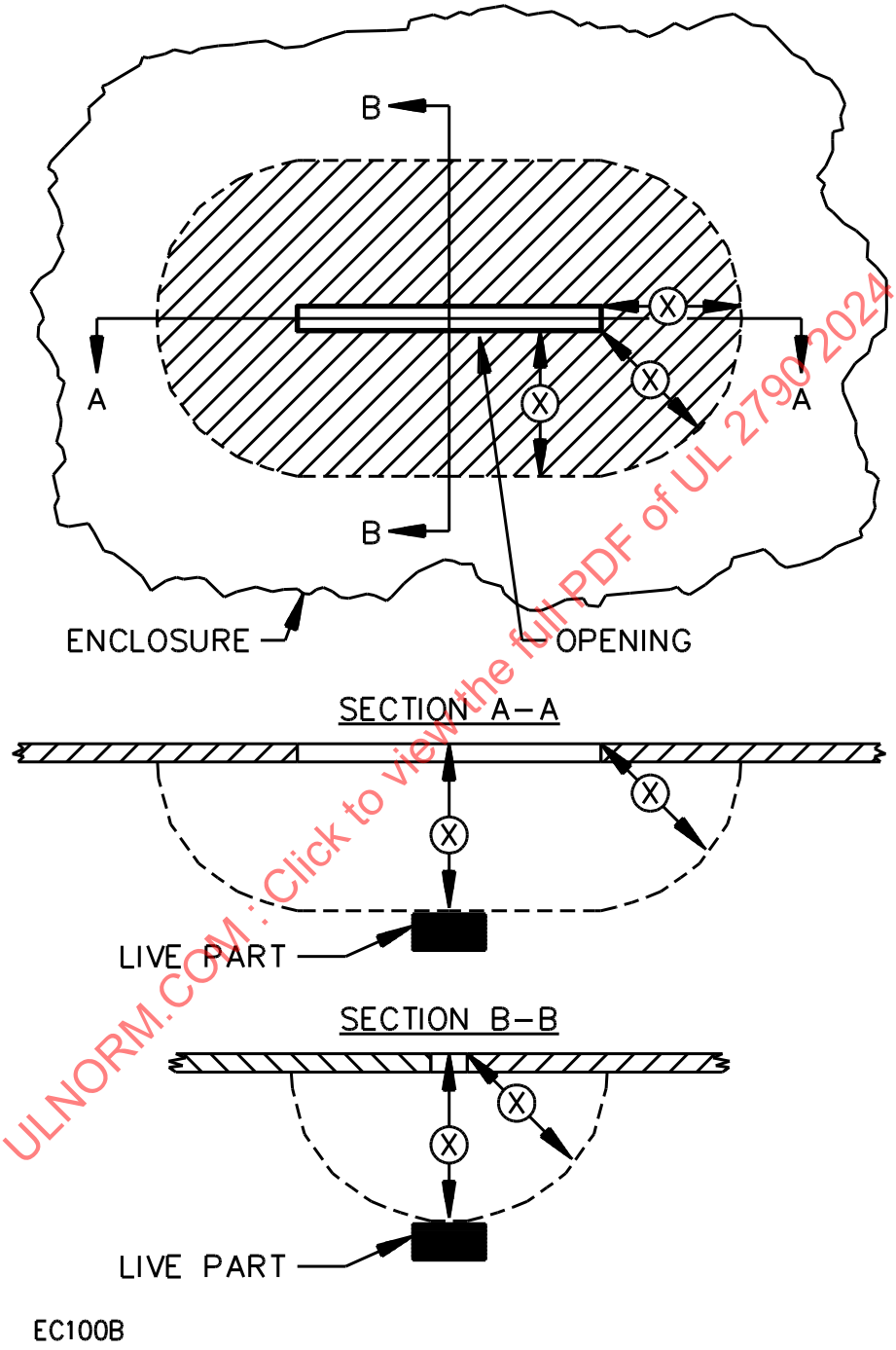


Figure 8.3

Opening in enclosure



The opening is acceptable if, within the enclosure, there is no uninsulated live part or enamel-insulated wire:

a) Less than X inches (mm) from the perimeter of the opening, as well as

b) Within the volume generated by projecting the perimeter X inches (mm) normal to its plane. X equals five times the diameter of the largest diameter rod which can be inserted through the opening, but not less than 4 inches (102 mm).

8.3 Doors and covers

8.3.1 A cover or access panel of an enclosure for uninsulated live parts shall be provided with means for securing it in place.

8.3.2 A hinged or pivoted panel or cover shall be positioned or arranged so that it is not subject to falling or swinging due to gravity or normal vibration in such a manner as to cause injury to persons by the panel or cover, or by hazardous moving parts or uninsulated live parts.

8.3.3 The assembly incorporating overcurrent protective devices shall be arranged so that fuses can be replaced and manual-reset devices can be reset, as applicable, without removing parts other than a service cover or panel and a cover or door enclosing the device. See 8.3.7.

8.3.4 A required protective device shall be wholly inaccessible from outside the assembly without opening a door or cover, except that the operating handle of a circuit breaker, the operating button of a manually operable motor protector, the reset button of a manually resettable pressure switch, and similar parts may project outside the boiler assembly enclosure.

8.3.5 An opening in an enclosure to provide clearance around a dial, knob, lever, or handle shall not allow the entrance of a rod having a diameter of 9/64 inch (3.6 mm) at any setting or position of the dial, knob, lever, or handle.

8.3.6 A fuseholder shall be so constructed, installed, or protected that adjacent uninsulated high-voltage live parts within 4 inches (102 mm), other than the screw shell of a plug fuseholder, cartridge fuse clips, or wiring terminals to the fuseholder, will not be exposed to contact by persons removing or replacing fuses. An insulating barrier of vulcanized fiber or equivalent material employed for this purpose shall be not less than 0.028 inch (0.71 mm) in thickness.

8.3.7 The door or cover of an enclosure shall be hinged if it gives access to fuses or any motor overload protective device, the normal functioning of which requires renewal, or if it is necessary to open the cover in connection with the normal operation of the protective device such as resetting a manual reset overload protective device.

Exception: A hinged cover is not required for a device in which the only fuses enclosed are:

a) Control-circuit fuses of 2 amperes or less, provided the fuses and control-circuit loads, other than a fixed control-circuit load, such as pilot lamp, are within the same enclosure;

b) Extractor-type fuses each with its own enclosure; or

c) Fuses in low-voltage circuits.

8.3.8 Hinged covers, where required, shall not depend solely upon screws or other similar means requiring the use of tools to hold them closed, but shall be provided with a catch or spring latch.

8.3.9 A spring latch, a magnetic latch, a dimple or any other mechanical arrangement that will hold the door in place and would require some effort on the user's part to open, is an acceptable means for holding the door in place as required in 8.3.8.

8.3.10 A door or cover giving direct access to fuses in other than low-voltage circuits shall shut closely against a 1/4 inch (6.4 mm) rabbet or the equivalent, or shall have either turned flanges for the full length of four edges or angle strips fastened to it. Flanges or angle strips shall fit closely with the outside of the wall of the box proper and shall overlap the edges of the box not less than 1/2 inch (12.7 mm). A

construction which affords equivalent protection, such as a fuse enclosure within an outer enclosure, or a combination of flange and rabbet, is acceptable.

8.3.11 Strips used to provide rabbets, or angle strips fastened to the edges of a door, shall be secured at not less than two points, not more than 1-1/2 inches (41.1 mm) from each end of each strip and at points between these end fastenings not more than 6 inches (152 mm) apart.

8.3.12 A plate or plug for an unused conduit opening or other hole in the enclosure shall have a thickness not less than:

a) 0.014 inch (0.36 mm) for steel or 0.019 inch (0.48 mm) for nonferrous metal for a hole having a 1/4 inch (6.4 mm) maximum dimensions; and

b) 0.027 inch (0.68 mm) for steel or 0.032 inch (0.81 mm) for nonferrous metal for a hole having a 1-3/8 inch (34.9 mm) maximum dimensions.

A closure for a larger hole shall have a thickness equal to that required for the enclosure of the device or a standard knockout seal shall be used. Such plates or plugs shall be securely mounted.

8.3.13 An electron tube or similar glass-enclosed device shall be protected against mechanical damage.

8.4 Field wiring system connection

8.4.1 If threads for the connection of conduit are tapped all the way through a hole in an enclosure wall, or if an equivalent construction is employed, there shall be not less than three nor more than five threads in the metal, and the construction of the device shall be such that a conduit bushing can be attached.

8.4.2 If threads for the connection of conduit are not tapped all the way through a hole in an enclosure wall, conduit hub, or the like, there shall be not less than 3-1/2 threads in the metal and there shall be a smooth, rounded inlet hole for the conductors which shall afford protection to the conductors equivalent to that provided by a standard conduit bushing and which shall have an internal diameter approximately the same as that of the corresponding trade size of rigid conduit.

8.4.3 An enclosure threaded for support by rigid conduit shall provide at least five full threads for engaging with the conduit.

8.4.4 A knockout in a sheet metal enclosure shall be capable of being removed without undue deformation of the enclosure.

8.4.5 A knockout shall be provided with a flat surrounding surface for seating of a conduit bushing, and shall be so located that installation of a bushing at any knockout likely to be used during installation will not result in spacings between uninsulated live parts and the bushing of less than those required.

9 Field Wiring

9.1 General

9.1.1 Provision shall be made for connection of a wiring system that would be suitable for power supply in accordance with the National Electrical Code, NFPA 70.

9.1.2 The location of an outlet box or compartment in which field wiring connections are to be made shall be such that these connections may be inspected after the equipment is installed as intended.

9.1.3 The connections shall be accessible without removing parts other than a service cover or panel and the cover of the outlet box or compartment in which the connections are made. A component intended for use as the cover of an outlet box or compartment may serve as a cover.

9.1.4 The size of a junction box in which field-installed conductors are to be connected by splicing shall be not less than that indicated in Table 9.1. A conductor passing through the box is counted as one conductor, and each conductor terminating in the box is also counted as one conductor. A field-furnished conductor for high-voltage circuits is considered to be not smaller than 14 AWG (2.1 mm^2).

Table 9.1
Size of junction boxes

Size of conductor AWG (mm^2)	Free space within box for each conductor, cubic inches (cm^3)
16 or smaller (1.3 or less)	1.5 (24.6)
14 (2.1)	2.0 (32.8)
12 (3.3)	2.25 (36.9)
10 (5.3)	2.5 (41.0)
8 (8.3)	3.0 (49.2)

9.1.5 A knockout for connection of a field wiring system to a terminal box or compartment shall accommodate conduit of the trade size determined by applying Table 9.2.

Table 9.2
Trade size of conduit in inches[a]

Wire size		Number of wires				
AWG	(mm^2)	2	3	4	5	6
14	(2.1)	1/2	1/2	1/2	1/2	1/2
12	(3.3)	1/2	1/2	1/2	3/4	3/4
10	(5.3)	1/2	1/2	1/2	3/4	3/4
8	(8.4)	3/4	3/4	1	1	1-1/4
6	(13.3)	3/4	1	1	1-1/4	1-1/4
4	(21.1)	1	1	1-1/4	1-1/4	1-1/2
3	(26.7)	1	1-1/4	1-1/4	1-1/2	1-1/2
2	(33.6)	1	1-1/4	1-1/4	1-1/2	2
1	(42.4)	1-1/4	1-1/4	1-1/2	2	2
0	(53.5)	1-1/4	1-1/2	2	2	2-1/2
2/0	(67.4)	1-1/2	1-1/2	2	2	2-1/2
3/0	(85.0)	1-1/2	2	2	2-1/2	2-1/2
4/0	(107.2)	2	2	2-1/2	2-1/2	3

[a] This table is based on the assumption that all conductors will be of the same size and there will be no more than six conductors in the conduit. If more than six conductors will be involved or if all of them are not of the same size, the internal cross-sectional area of the smallest conduit that may be used is determined by multiplying by 2.5 the total cross-sectional area of the wires, based on the cross-sectional area of type THW wire.

9.1.6 Wiring exterior to an appliance assembly between the burner assembly and a limit control, a primary safety control, or a motor controller, that can be done readily with a wire enclosed in conduit or

with metal-clad cable in accordance with the National Electrical Code, NFPA 70, need not be furnished by the manufacturer as part of the appliance assembly if adequate instructions for installing such wiring are furnished with each appliance assembly. See 9.1.4.

9.1.7 A box or enclosure, included as part of the assembly and in which a branch circuit supplying power to the appliance assembly is to be connected, shall not require that it be moved for normal care of the unit. This requirement does not apply to separate limit controls and stack switches, where permitted, to which metal-clad cable or flexible metallic conduit is to be directly attached.

9.1.8 A box or enclosure in which field installed conductors are to be connected as indicated in 9.1.5 – 9.1.7, and 9.1.9 shall be so located that the temperature of conductors within the box or surfaces of the box likely to be in contact with the conductors will not exceed that specified for a wire having a 140°F (60°C) temperature rating when the assembly is tested in accordance with these requirements.

9.1.9 Except as otherwise permitted by 15.3.1, wiring to be done in the field between the assembly and devices not attached to the appliance assembly or between separate devices which are field installed and located, shall conform to these requirements if done with a 140°F (60°C) rated wire enclosed in suitable conduit or metal-clad cable.

9.1.10 The wiring of the appliance may terminate in a length of flexible metal conduit with an outlet box, control box, or equivalent enclosure intended for connection of the product to the wiring system specified in 9.1.1. If the conduit terminates in an outlet box larger than 4 by 4 by 2 inches (102 by 102 by 51 mm) for splice connection, locknuts on the fittings are not acceptable as a means to prevent loosening of the conduit fittings. A grounding conductor of the size specified in the National Electrical Code, NFPA 70, shall be included unless:

a) The total length of flexible metal conduit of any ground return path in the product is not more than 6 feet (1.83 m);

b) No circuit conductor protected by an overcurrent-protective device rated at more than 20 amperes is included; and

c) The conduit is no larger than 3/4 inch trade size, or the fittings for the conduit are identified as providing grounding.

9.2 Leads and terminals

9.2.1 Wiring terminals or leads not less than 6 inches (152 mm) long for connection of field-wiring conductors of at least the size required by the National Electrical Code, NFPA 70, corresponding to the marked rating of the assembly shall be provided.

9.2.2 Leads may be less than 6 inches (152 mm) in length if it is evident that the use of a longer lead might result in a risk of fire, electric shock, or injury to persons.

9.2.3 Leads intended for connection to an external circuit shall be provided with strain relief if stress on the lead may be transmitted to terminals, splices, or internal wiring which may cause the lead to separate from its termination or result in damage to the lead from sharp edges. Each lead shall be capable of withstanding a pull of 10 pounds (44.5 N) for 1 minute without damage to the assembly.

9.2.4 An identified (grounded) terminal or lead shall not be electrically connected to a single-pole manual switching device which has an OFF position or to a single-pole overcurrent (not thermal) protective device.

9.2.5 At terminals, stranded conductors shall be prevented from contacting other uninsulated live parts and from contacting dead metal parts. This may be accomplished by use of pressure-terminal connectors, soldering lugs, crimped eyelets, soldering all strands of the wire together, or equivalent means. An open

slot-type connector shall not be used unless it is constructed to reduce the likelihood of disconnection resulting from loosening of the clamping means. The shanks of terminal connectors shall be protected by insulating tubing, or the equivalent, if the required spacings may be reduced as a result of loosening of the clamping means. The thickness of the insulation on the shanks shall be not less than 0.028 inch (0.71 mm).

9.2.6 Field wiring terminals shall be secured to their supporting surfaces by methods other than friction between surfaces so that they will be prevented from turning or shifting in position if such motion may result in reduction of spacings to less than those required. This may be accomplished by two screws or rivets; by square shoulders or mortices; by a dowel pin, lug, or offset; by a connecting strap or clip fitted into an adjacent part; or by some other equivalent means.

9.2.7 Conductors intended for connection to a grounded neutral line shall be identified, that is, finished a white or gray color. All other current-carrying conductors visible to the installer shall be finished in colors other than white, gray, or green. A terminal for connection of a grounded conductor shall be identified by a metallic-plated coating, substantially white in color and shall be readily distinguishable from other terminals, or it shall be identified in some other manner, such as on an attached wiring diagram.

9.2.8 Leads provided for spliced connections to an external high-voltage circuit shall not be connected to wire-binding screws or pressure terminal connectors, located in the same compartment as the splice or visible to the installer, unless the screws or connectors are rendered unusable for field wiring connections or the leads are insulated at the unconnected ends.

9.2.9 Terminal parts by which field-wiring connections are made shall consist of soldering lugs or pressure terminal connectors secured in place in accordance with the requirements in 9.2.5, except that for 10 AWG (5.3 mm^2) and smaller wires, the parts to which wiring connections are made may consist of clamps or wire binding screws with cupped washers, terminal plates having upturned lugs, or the equivalent, to hold the wire in position.

9.2.10 A wire binding screw at a high-voltage wiring terminal for field connection shall not be smaller than No. 10 (4.8 mm major diameter).

Exception No. 1: A No. 8 (4.2 mm major diameter) screw may be used for the connection of a conductor not larger than 14 AWG (2.1 mm^2).

Exception No. 2: A No. 6 (3.5 mm major diameter) screw may be used for the connection of a 16 or 18 AWG (1.3 or 0.82 mm^2) control-circuit conductor.

9.2.11 A terminal plate for a wire binding screw shall be of metal not less than 0.030 inch (0.76 mm) in thickness for a 14 AWG (2.1 mm^2) or smaller wire, and not less than 0.050 inch (1.27 mm) in thickness for a wire larger than 14 AWG (2.1 mm^2); and in either case there shall be not less than two full threads in the metal.

9.2.12 A terminal plate formed from stock having the minimum required thickness may have the metal extruded at the tapped hole for the binding screw so as to provide two full threads.

9.2.13 A wire binding screw shall thread into metal.

10 Internal Wiring

10.1 General

10.1.1 The wiring of high-voltage circuits shall conform to the requirements in this Section.

10.1.2 Wiring shall be done with insulated conductors having current carrying capacity, voltage, and temperature ratings consistent with their use. A conductor, other than an integral part of a component, shall be not smaller than 18 AWG (0.82 mm^2).

10.1.3 Except as indicated in 10.2.2, the wiring for each device assembly circuit shall be furnished by the manufacturer as part of the burner assembly.

10.1.4 If insulated conductors rated for use at temperatures in excess of 140°F (60°C) are required, such wiring shall be furnished as part of the assembly and the devices to be connected by such wiring shall be factory-located on the equipment.

10.2 Methods

10.2.1 Electrical wiring to a part which must be moved for normal maintenance and servicing shall be arranged so that the part may be moved without breaking soldered connections or disconnecting conduit. Conductors to be disconnected from terminals of such part shall terminate in eyelets or connectors. If the wiring to a part which functions also as an access plate or cover, that is, a transformer closing the access to the nozzle assembly, is not readily detachable, the assembly shall include provision for support of that part by means other than the wiring when the part is moved for servicing. Any allowable movement of such part shall not unduly twist, bend, or pull the wiring.

10.2.2 Conductors shall be enclosed within conduit, electrical metallic tubing, metal raceway, electrical enclosure, or metal-clad cable, except as permitted by 10.2.15.

Exception: Factory wiring involving a potential of not more than 300 volts between parts attached to the same assembly with a predetermined fixed relationship one to the other may be done with Type SO or ST cord, provided all of the following conditions are fulfilled:

a) It is not practical to do the wiring in accordance with 10.2.2;

b) The cord is not required to be bent, twisted, or otherwise displaced to render normal maintenance and service; and

c) The length of cord exterior to the assembly is not more than 4 inches (102 mm) and strain relief is provided.

10.2.3 Group A of Table 10.1 includes some wiring materials suitable for use if enclosed as indicated in 10.2.2.

Table 10.1
Typical wiring materials

Group	Type of wire, cord, or appliance wiring material with insulation thickness shown at the right corresponding to wire sizes indicated	Wire size		Insulation thickness	
		AWG	(mm^2)	Inch	(mm)
A	FFH-2, TF, TFF, TFN, TFFN, SF-2, SFF-2, RH, RHH, RHW, T, THW, XHHW, MTW, THWN, TW, PF, PFF, PGF, PGFF, RFH-2, RFHH-2, RFHH-3 or thermoplastic appliance wiring material.	10 and smaller	(5.3)	2/64	(0.8)
		8	(8.3)	3/64	(1.2)
		6	(13.3)	4/64	(1.6)
		4	(21.2)	4/64	(1.6)
		3	(25.7)	4/64	(1.6)

Table 10.1 Continued on Next Page

Table 10.1 Continued

Group	Type of wire, cord, or appliance wiring material with insulation thickness shown at the right corresponding to wire sizes indicated	Wire size		Insulation thickness	
		AWG	(mm^2)	Inch	(mm)
		2	(33.6)	4/64	(1.6)
		1	(42.4)	5/64	(2.0)
		1/0	(53.5)	5/64	(2.0)
		2/0	(67.4)	5/64	(2.0)
		3/0	(85.0)	5/64	(2.0)
		4/0	(107.0)	5/64	(2.0)
B	SEO, SEOO, SJE, SJEO, SO, ST, SJO, SJT, S, SE, SJ, SJOO, SJTO, SJTOO, SOO, STO, STOO, or appliance wiring material with thermoplastic or neoprene insulation	18	(0.82)	4/64	(1.8)
		16	(1.3)	4/64	(1.6)
		14	(2.1)	5/64	(2.0)
		12	(3.3)	5/64	(2.0)
		10	(5.3)	5/64	(2.0)
		8	(8.3)	6/64	(2.4)
		6	(13.3)	8/64	(3.2)

Thermoplastic wiring materials, as referenced in group A, with insulation thickness of 2/64 inch (0.8 mm) for 16 or 18 AWG (1.3 or 0.82 mm^2) and 3/64 inch (1.2 mm) for 14, 12, 10, or 8 AWG (2.1, 3.3, 5.3, or 8.3 mm^2), are considered equivalent to the wiring material referenced in group B, when the conductors are covered with 1/32 inch (0.8 mm) wall thickness thermoplastic insulating tubing of a type suitable for the purpose from the standpoint of dielectric properties, heat resistance, moisture-resistance, flammability, and the like.

10.2.4 Flexible metal conduit, if used, shall be not smaller than 3/8 inch (9.5 mm) electrical trade size. This does not apply to parts of components, such as conduit protecting flame sensor leads.

10.2.5 Flexible metal conduit shall be mechanically secured at intervals not exceeding 4-1/2 feet (1.37 m) and within 12 inches (305 mm) on each side of every junction box except for lengths not over 36 inches (914 mm) where flexibility is necessary.

10.2.6 All splices and connections shall be mechanically secure and bonded electrically. A soldered connection shall be made mechanically secure before being soldered if breaking or loosening of the connection may result in risk of fire, electric shock, or injury to persons.

10.2.7 A splice shall be provided with insulation equivalent to that required for the wires involved if permanence of spacing between the splice and other metal parts is not ensured.

10.2.8 A splicing device, such as a fixture-type splicing connector, pressure wire connector, and the like, may be employed if the device has insulation suitable for the voltage to which it is subjected. Thermoplastic tape wrapped over a sharp edge is not acceptable.

10.2.9 Each splice shall be enclosed by being installed in a junction box, control box, or other compartment in which high-voltage wiring materials may be employed.

10.2.10 Splices shall be located, enclosed, and supported so that they are not subject to damage, flexing, motion, or vibration.

10.2.11 A splice is considered to be adequately enclosed when installed in a junction box, control box, or other enclosed compartment in which wiring materials, as specified in Group A of Table 10.1, may be

employed. Splices in enclosed machinery compartments are to be secured to a fixed member in the compartment so that they are not subject to movement or damage during servicing.

10.2.12 At all points where conduit or metal tubing terminates, the conductor shall be protected from abrasion. If metal-clad cable is used, an insulating bushing or its equivalent shall be provided between the conductors and the metal cladding, and the connector or clamp shall be of such design that the insulating bushing or its equivalent will be visible for inspection.

10.2.13 A wireway shall be such that the interconnection of sections and fittings will provide a rigid mechanical assembly and ensure electrical conductivity. The interior of the wireway shall be free from burrs and sharp corners or edges which might cause damage to the insulation on wires.

10.2.14 All wiring shall be supported and routed to prevent damage due to sharp edges or moving parts.

10.2.15 Cords or appliance wiring material as referenced in Group B of Table 10.1 may be employed if the wiring is enclosed by a casing or compartment conforming to all of the following:

a) There are no openings in the bottom, unless a U-shaped channel or trough is located under the wiring and the wires do not project through the plane of the top of the trough or channel;

b) If the appliance is for installation only on noncombustible flooring, the bottom of such compartment may be open provided all sides of the compartment extend to the floor level;

c) Louvers or openings in other than the bottom will not permit entrance of a rod having a diameter of 1/2 inch (12.7 mm), and openings for such items as pipe or conduit are not more than 1/2 inch in diameter larger than the object that will be installed through the opening;

d) Openings are not closer than 6 inches (152 mm) to the wiring unless metallic barriers or baffles are placed between the wiring and the openings; and

e) Combustible material, other than electrical insulation, located within the casing or compartment is separated from such wiring material.

10.2.16 With reference to 10.2.15(e), plastic materials shall be classified as Type V-0, V-1, V-2, 5V, HF-1, or HF-2 in accordance with requirements in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, and other nonmetallic materials shall have equivalent characteristics.

10.2.17 Cords and other wiring material permitted in accordance with 10.2.15 shall be arranged to avoid being physically damaged, such as by closely following surfaces, and shall be supported. Strain relief, where required, shall be provided.

10.2.18 Holes in walls or partitions through which insulated wires or cords pass and on which they may bear shall be provided with smoothly rounded bushings or surfaces upon which the wires or cords may bear, to prevent abrasion of the insulation. Bushings, if required, shall be ceramic, phenolic, cold-molded composition, fiber, or equivalent material.

10.2.19 A fiber bushing shall be not less than 3/64 inch (1.2 mm) in thickness, shall be so located that it will not be exposed to moisture, and shall not be employed where it will be subjected to a temperature higher than 194°F (90°C) under normal operating conditions.

10.2.20 To provide an acceptable unbushed opening in sheet metal, not requiring a bushing, usually requires roll or extrusion of the metal around the opening, or both, or the insertion of a grommet conforming to 10.2.18.

10.3 Short-circuit protection

10.3.1 Conductors of motor circuits having two or more motors, one or more of which are thermal or overcurrent protected and wired for connection to one supply line shall withstand the conditions of a short-circuit test without creating a risk of fire or electric shock. See Short-Circuit Test, Section 61.

Exception: Conductors that conform to the following are considered acceptable without test:

a) Conductors that have not less than one-third the ampacity of the required branch-circuit conductors; or

b) Conductors that are 18 AWG (0.82 mm^2) or larger and not more than 4 feet (1.2 m) in length provided that the circuit will be protected by a fuse or HACR Type circuit breaker rated 60 amperes or less as specified on the product nameplate or provided as part of the product and acceptable for branch-circuit protection. This applies to any of the wiring materials specified in this standard, including those enclosed those enclosed in raceways; or

c) Conductors that serve as jumper leads between controls providing the length of the leads does not exceed 3 inches (76 mm) or the conductors are located in a control panel.

10.3.2 Factory wiring of a low-voltage safety circuit may be done with SP-2 cord having all-neoprene insulation, SPT-2 cord or appliance wiring material having neoprene, thermoplastic, or equally durable insulation of equivalent thickness, or power limited circuit cable, if such wiring is located in a cavity or compartment of an appliance and is adequately shielded from harm.

11 Separation of Circuits

11.1 Unless provided with insulation for the highest voltage involved, insulated conductors of different internal wiring circuits shall be separated by barriers or shall be segregated; and shall also be so separated or segregated from uninsulated live parts connected to different circuits or opposite-polarity parts of the same circuit.

11.2 Segregation of insulated conductors may be accomplished by clamping, routing, or equivalent means which provides permanent separation from insulated or uninsulated live parts of a different circuit.

11.3 Field-installed conductors of any circuit shall be segregated or separated by barriers from:

a) Field-installed and factory-installed conductors connected to any other circuit, unless the conductors of both circuits are insulated for the maximum voltage of either circuit;

b) Uninsulated live parts of any other circuit; and

c) Any uninsulated live parts whose short-circuiting may permit operation of the appliance that may result in a risk of fire, electric shock, or injury to persons except that a construction in which field-installed conductors may make contact with wiring terminals is acceptable, provided that conductors having insulation at least equivalent to those referenced in group A of Table 10.1 are or will be installed when wired in accordance with the National Electrical Code, NFPA 70.

11.4 Segregation between field installed conductors and from uninsulated live parts connected to different circuits may be accomplished by arranging the location of the openings in the enclosure for the various conductors, with respect to the terminals or other uninsulated live parts, so that there is no likelihood of the intermingling of the conductors or parts of different circuits. If:

a) The number of openings in the enclosure does not exceed the minimum required for proper wiring and if each opening is located opposite a set of terminals, it is to be assumed, for the

purpose of determining compliance with 11.3, that the conductors entering each opening will be connected to the terminals opposite the opening.

b) More than the minimum number of openings are provided, the possibility of conductors entering at points other than opposite the terminals to which they are intended to be connected and contacting insulated conductors or uninsulated live parts connected to a different circuit is to be investigated

11.5 To determine if an appliance complies with the requirements of 11.3, it is to be wired as it would be in service and in doing a reasonable amount of slack is to be left in each conductor within the enclosure, and no more than average care is to be exercised in stowing this slack into the wiring compartment.

11.6 If a barrier is used to provide separation between the wiring of different circuits or between operating parts and field installed conductors, it shall be of metal or insulating material and shall be held in place.

11.7 A metal barrier shall have a thickness at least as great as that required by Table 8.1 or Table 8.2, whichever applies, based on the size of the barrier. A barrier of insulating material shall be not less than 0.028 inch (0.71 mm) in thickness and shall be of greater thickness if its deformation may be readily accomplished so as to defeat its purpose. Any clearance at the edges of a barrier shall be not more than 1/16 inch (1.6 mm) wide.

11.8 Openings in a barrier for the passage of conductors shall be not larger than 1/4 inch (6.4 mm) in diameter and shall not exceed in number, on the basis of one opening per conductor, the number of wires which will need to pass through the barrier. The closure for any other opening shall present a smooth surface wherever an insulated wire may be in contact with it; and the area of any such opening, with the closure removed, shall not be larger than required for the passage of the necessary wires.

11.9 Openings in a barrier for the passage of conductors shall be not larger than 1/4 inch (6.4 mm) in diameter and shall not exceed in number, on the basis of one opening per conductor, the number of wires which will need to pass through the barrier. The closure for any other opening shall present a smooth surface wherever an insulated wire may be in contact with it; and the area of any such opening, with the closure removed, shall not be larger than required for the passage of the necessary wires.

11.10 Two or more transformer devices supplying circuits classified as Class 2, low-voltage circuits provided as a part of the appliance shall be treated as two separate circuits each having its own separate wiring compartment, and the output of each circuit shall be marked to warn that the separation shall be maintained.

12 Bonding for Grounding

12.1 Exposed or accessible noncurrent carrying metal parts which may become energized, and which may be contacted by the user or by service personnel during service operations likely to be performed when the appliance is energized, shall be electrically connected to the point of connection of an equipment ground.

12.2 Except as indicated in 12.3, uninsulated metal parts of cabinets, electrical enclosures, motor frames and mounting brackets, controller mounting brackets, capacitors and other electrical components, interconnecting tubing and piping valves, and the like, are to be bonded for grounding if they may be contacted by the user or serviceman.

12.3 Metal parts, as described below, need not be grounded:

a) Adhesive-attached metal-foil markings, screws, handles, etc., which are located on the outside of enclosures or cabinets and isolated from electrical components or wiring by grounded metal parts;

b) Isolated metal parts, such as magnet frames and armatures, small assembly screws, and the, which are separated from wiring and uninsulated live parts;

c) Panels and covers which do not enclose uninsulated live parts if insulated parts and wiring are separated from the panel or cover; or

d) Panels and covers which are insulated from electrical components and wiring by an attached insulating barrier of vulcanized fiber, varnished cloth, phenolic composition, or similar material not less than 1/32 inch (0.8 mm) thick.

12.4 A component, such as a switch, likely to become separated from its normal grounding means for purposes of testing or adjustment while the equipment is energized, is to be provided with a grounding conductor not requiring removal for such service.

12.5 Splices shall not be employed in wire conductors used for bonding.

12.6 Metal-to-metal hinge bearing members may be considered as a means for bonding a door for grounding.

12.7 A separate bonding conductor shall be of material rated for use as an electrical conductor. Ferrous metal parts in the grounding path shall be protected against corrosion by enameling, galvanizing, plating, or equivalent means. A separate bonding conductor or strap shall:

a) Be protected from mechanical damage, such as by being located within the confines of the outer enclosure or frame; and

b) Not be secured by a removable fastener used for any purpose other than bonding for grounding unless the bonding conductor is unlikely to be omitted after removal and replacement of the fastener.

12.8 The bonding shall be by a positive means, such as by clamping, riveting, bolted or screwed connection, or by welding, soldering, or brazing with materials having a softening or melting point greater than 850°F (454°C). The bonding connection shall penetrate nonconductive coatings such as paint or vitreous enamel.

12.9 A connection that depends upon the clamping action exerted by rubber or similar materials is acceptable if it complies with 12.11 under any degree of compression permitted by a variable clamping device and if the results are still acceptable after exposure to the effects of oil, grease, moisture, and thermal degradation which are likely to occur in service. The effect of assembling and disassembling, for maintenance purposes, such a clamping device is to be considered with respect to the likelihood of the clamping device being reassembled in its intended position.

12.10 Where the bonding means depend on screw threads, two or more screws or two full threads of a single screw engaging metal is considered in compliance with 12.8.

12.11 If the adequacy of a bonding connection cannot be determined by examination, or if a bonding conductor is smaller than required by 12.12 – 12.14, it shall be considered acceptable if the connecting means does not open:

a) When carrying for the time indicated in Table 12.1 twice the current equal to the rating of the branch-circuit overcurrent device required to protect the equipment; and

b) During a short-circuit test in series with a fuse of proper rating. See Short-Circuit Test, Section 61.

Table 12.1
Duration of current flow, bonding-conductor test

Rating of overcurrent device, Amperes	Minimum duration of current flow, minutes
30 or less	2
31 – 60	4
61 – 100	6
101 – 200	8

12.12 The size of a conductor or strap employed to bond an electrical enclosure or motor frame shall be based on the rating of the branch-circuit overcurrent device to which the equipment will be connected. Except as indicated in 12.11, the size of the conductor or strap shall be in accordance with Table 12.2.

Table 12.2
Bonding wire conductor size

Rating of overcurrent device, amperes	Size of bonding conductor[a]			
	Copper wire		Aluminum wire	
	AWG	(mm^2)	AWG	(mm^2)
15	14	(2.1)	12	(3.3)
20	12	(3.3)	10	(5.3)
30	10	(5.3)	8	(8.3)
40	10	(5.3)	8	(8.3)
60	10	(5.3)	8	(8.3)
100	8	(8.3)	6	(13.3)
200	6	(13.3)	4	(21.2(

[a] Or equivalent cross-sectional area.

12.13 A bonding conductor to a component or electrical enclosure is not required to be larger than the size of the conductors supplying power to the component(s) within the enclosure.

12.14 If more than one size of branch-circuit overcurrent device is involved, the size of the bonding conductor is to be based on the rating of the overcurrent device intended to provide ground-fault protection for the component bonded by the conductor. For example, if a motor is individually protected by a branch-circuit overcurrent device smaller than other overcurrent devices used with the equipment, a bonding conductor for that motor is sized on the basis of the overcurrent device intended for ground-fault protection of the motor.

12.15 The following are considered to constitute means for connection to a ground:

a) In equipment intended to be connected to a metal-enclosed wiring system – A knockout or equivalent opening in a metal enclosure intended to receive the power-supply system; and

b) In equipment intended to be connected by a nonmetal-enclosed wiring system, for example, metal-clad cable – An equipment grounding terminal or lead.

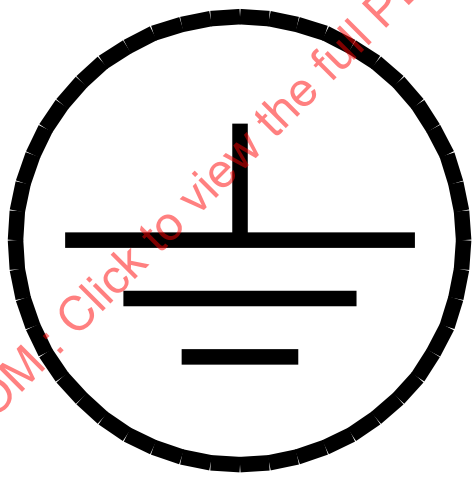
12.16 A terminal for connection of an equipment-grounding conductor shall be capable of securing a conductor of the size required for the particular application, in accordance with the National Electrical Code, NFPA 70.

12.17 A soldering lug, a push-in (screwless) connector, or a quick-connect or similar friction fit connector shall not be used for the terminal for the field installed grounding conductor.

12.18 A wire-binding screw intended for the connection of an equipment-grounding conductor shall have a green colored head that is hexagonal, slotted, or both. A pressure wire connector intended for connection of such a conductor shall be identified by being marked "G", "GR", "GROUND", "GROUNDING", by the symbol in Figure 12.1, or by a marking on a wiring diagram provided on the equipment. The wire-binding screw or pressure wire connector shall be secured to the frame or enclosure and shall be so located that it is unlikely to be removed during normal servicing. At a wire-binding screw, upturned lugs, or the equivalent, shall be provided to retain the conductor. If a pressure connector is used adjacent to the connectors intended for the supply conductors and if it could be mistaken for the neutral of a grounded supply, a marking shall be additionally provided indicating "EQUIPMENT GROUND" and/or identifying the connector by a green color.

Figure 12.1

Grounding symbol



12.19 The surface of an insulated lead intended for the connection of an equipment-grounding conductor shall be finished continuous green color or a continuous green color with one or more yellow stripes, and no other lead visible to the installer shall be so identified.

13 Mounting of Electrical Components

13.1 A switch, fuseholder, lampholder, or similar electrical component shall be mounted to prevent it from turning, except as noted in 13.2 and 13.3.

13.2 The requirement that a switch be prevented from turning may be waived if all of the following conditions are met:

a) The switch is of a plunger or other type that does not tend to rotate when operated. A toggle switch is considered to be subject to forces that tend to turn the switch during normal operation of the switch;

b) The means for mounting the switch makes it unlikely that operation of the switch will loosen it;

c) The spacings are not reduced below the required values if the switch rotates; and

d) The normal operation of the switch is by mechanical means rather than by direct contact by persons.

13.3 A lampholder of the type in which the lamp cannot be replaced, such as a neon pilot or indicator light in which the lamp is sealed in a nonremovable jewel, need not be prevented from turning if rotation cannot reduce spacings below the required values.

13.4 The means for preventing turning is to consist of more than friction between surfaces. A toothed lock washer which provides both spring take-up and an interference lock is acceptable as the means for preventing a small stem-mounted switch or other device having a single-hole mounting means from turning.

13.5 Uninsulated live parts shall be so secured to the base or mounting surface that they will be prevented from turning or shifting in position if such motion may result in a reduction of spacings below the acceptable values.

14 Motors

14.1 General

14.1.1 The enclosure of a motor shall have no openings which will permit a drop of liquid, or a particle falling vertically onto the motor, to enter the motor as applied to the assembly.

14.1.2 Conformance to 14.1.1 may be provided by the motor frame or by another enclosure, structure, shield, or a combination of two or more such items, and is to be determined with the motor applied to the assembly.

14.1.3 Motors having openings in the enclosure or frame shall be installed or shielded to prevent particles from falling out of the motor onto combustible material located within or under the assembly.

14.1.4 The requirement in 14.1.3 will necessitate the use of a barrier of nonflammable material under an open type motor unless:

a) The structural parts of the motor or the burner such as the bottom closure, provide the equivalent of such a barrier; or

b) The motor overload protection device provided with a single-phase motor is such that no burning insulation or molten material falls to the surface that supports the appliance when the motor is energized under each of the following fault conditions, as applicable to the particular type of motor:

1) Open main winding;

2) Open starting winding;

3) Starting switch short-circuited; and

4) Capacitor shorted, permanent split capacitor type; or

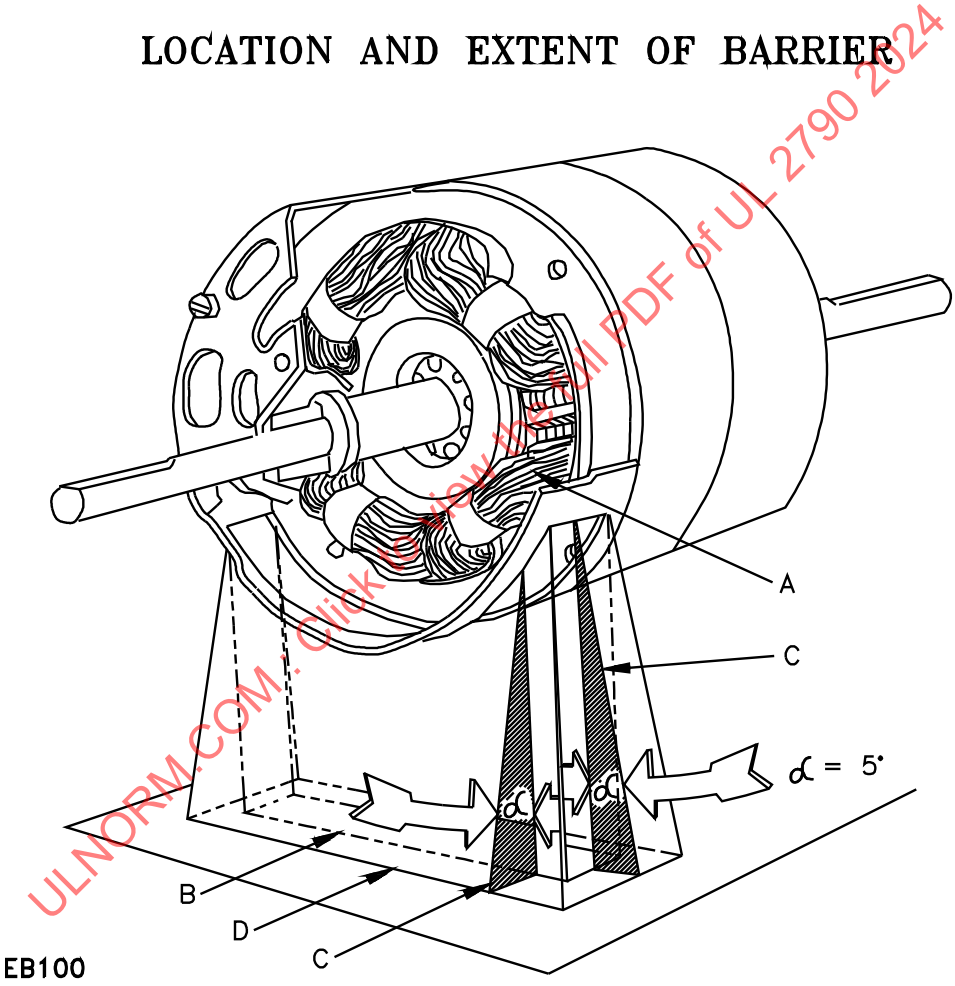
c) The motor is provided with motor protector in accordance with Motor Overload Protection, Section 14.2, that will prevent the temperature of the motor windings from becoming more than 275°F (125°C) under the maximum load below which the motor will run without causing the protector to cycle and from becoming more than 302°F (150°C) with the rotor of the motor locked.

d) The motor complies with the requirements for impedance-protected motors, see 14.2.5, and the motor winding will not exceed a temperature greater than 302°F (150°C) during the first 72 hours of operation with the rotor of the motor locked.

14.1.5 The barrier mentioned in 14.1.4 shall be horizontal, and have an area not less than that described in that illustration. Openings for drainage, ventilation, and the like, may be employed in the barrier provided that such openings would not permit molten metal, burning insulation, or the like to fall on combustible material.

Figure 14.1

Location and extent of barrier



A – Motor winding to be shielded by barrier. This is to consist of the entire motor winding if it is not otherwise shielded, and is to consist of the unshielded portion of a motor winding which is partially shielded by the motor enclosure or equivalent.

B – Projection of outline of motor winding on horizontal plane.

C – Inclined line which traces out minimum area of the barrier. When moving, the line is to be always:

1) tangent to the motor winding,

2) 5 degrees from the vertical, and

3) so oriented that the area traced out on a horizontal plane is maximum.

D – Location (horizontal) and minimum area for barrier. The area is to be that included inside the line of intersection traced out by the inclined line C and the horizontal plane of the barrier.

14.1.6 A motor shall be designed for continuous duty as indicated by the designation "CONTINUOUS" or "CONT" on the nameplate.

14.1.7 Motors shall comply with the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1.

14.2 Motor Overload Protection

14.2.1 Fuses shall not be used as motor overload protective devices unless the motor is adequately protected by the largest size fuse which can be inserted in the fuseholder.

14.2.2 In no case shall interruption of the circuit to a motor by the overcurrent or thermal protective device result in a risk of fire, electric shock, or injury to persons during operation of the equipment or the discharge of fuel that may result in a risk of fire or injury to persons. If a burner depends solely upon an electrical valve to stop the flow of fuel to the burner, the interruption of the circuit to the motor by the protective device shall also cause the interruption of the circuit to the valve.

14.2.3 Automatic-reset type protective devices shall not be used if the automatic reclosing of the circuit to the motor by the device may result in a risk of fire, electric shock, or injury to persons during operation of the equipment.

14.2.4 Overcurrent protective devices and thermal protective devices for motors shall comply with applicable short-circuit requirements for the class of protective device and shall, in addition, comply with the requirements of the Short-Circuit Test, Section 61.

14.2.5 All single-phase motors shall be protected by one or more of the following:

a) A separate device responsive to motor current and rated or set to trip at not more than the percentage of the motor nameplate full-load current rating as specified in Table 14.1.

b) A separate overload device, which combines the functions of overload and overcurrent protection and is responsive to motor current. Such a device shall be set at values not greater than the percentages of the motor nameplate full-load current rating as specified Table 14.1.

c) A thermal protective device or impedance protection complying with the Standard for Overheating Protection for Motors, UL 2111. If a motor protective electronic circuit relies on software as a protective component, that part of the software providing the required motor protection shall comply with software Class 1 in the Standard for Software in Programmable Components, UL 1998 or software Class B in Annex H of the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1.

d) Impedance protection complying with the Standard for Impedance Protected Motors, UL 1004-2.

Exception: Impedance protection may be accepted for motors which are determined to be adequately protected against overheating due to locked-rotor current, provided it is determined that the motor will not overheat under the performance requirements of this standard.

e) A protective device integral with the motor that complies with the Standard for Thermally Protected Motors, UL 1004-3. A motor intended to move air only, by means of an air-moving fan that is integrally attached, keyed, or otherwise fixed to the motor, is required to have locked-rotor protection only.

f) Protective electronic circuits integral to the motor that comply with the Standard for Electronically Protected Motors, UL 1004-7.

g) Protective electronic circuits that comply with 14.2.7.

h) Other protection that is shown by test to be equivalent to the protection specified in (a) to (g).

14.2.6 In reference to 14.2.5(a) and (b), if the percentage protection specified in Column A of Table 14.1 does not correspond to the percentage value of an overload device of a standard size, the device of the next higher size may be used. However, the device of the next higher size shall provide protection no higher than that indicated in Column B of Table 14.1.

Table 14.1
Overload relay size

	Maximum percentage protection	
	A	B
Motor with a marked service factor no less than 1.15	125	140
Motor with a marked temperature rise no more than 72°F (40°C)	125	140
Any other motor	115	130

14.2.7 Except as indicated in 14.2.5(c) and (f), a protective electronic circuit providing motor protection shall comply with one of the following:

a) Tests for Safety-Related Controls Employing Solid-State Devices, UL 991. When the protective electronic circuit is relying upon software as a protective component, that part of the software providing the required motor protection shall comply with the Standard for Tests for Software in Programmable Components, UL 1998. If software is relied upon to perform a safety function, it shall be considered software Class 1.

b) Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1 as well as the Standard for Automatic Electrical Controls for Household and Similar Use, Part 2: Particular Requirements for Temperature Sensing Controls, UL 60730-2-9. If software is relied upon to perform a safety function, it shall be considered software Class B.

Exception: A protective electronic circuit providing motor protection is not required to comply with UL 991 or UL 60730-1 if there is no risk of fire, electric shock or casualty hazard during abnormal testing with the protective electronic circuit rendered ineffective. The need for software to comply with UL 1998 or UL 60730-1 can be based on the actual construction and operation of the motor within the equipment. This could include a consideration of the protective electronic circuit being provided with independent redundant protective devices.

14.2.8 With reference to 14.2.7, the factors outlined in Table 14.2 shall be considered when judging the acceptability of a protective electronic circuit.

Table 14.2
Factors for Judging Protective Electronic Circuits

1	Conducting failure-mode and effect analysis (FMEA) for the protective circuits and functions.
2	Electrical supervision of critical components resulting in the control becoming permanently inoperative and disconnecting power.
3	Temperature ranges as follows: **Indoor Equipment:** 32.0 ±3.6°F (0.0 ±2°C) and 104 ±3.6°F (40.0 ±2°C) **Outdoor Equipment:** -31.0 ±3.6°F (–35.0 ±2°C) and 104 ±3.6°F (40.0 ±2°C)
4	Cycling test duration: 14 days
5	Endurance test duration: 100,000 cycles
6	Radio-frequency electromagnetic field immunity: A. To conducted disturbances[a] – test level 3 B. To radiated electromagnetic fields – field strength of 3 V/m
7	Humidity exposure: **Indoor Equipment:** 70 – 80°F (21.1 – 26.7°C) and minimum 50 percent relative humidity **Outdoor Equipment:** minimum 98 percent relative humidity
8	Electrical fast transient/burst immunity: **Outdoor Equipment:** test level 4 **For all equipment other than outdoor use:** test level 3
9	Surge immunity[a]: **Outdoor Equipment:** - installation Class 4 **For all equipment other than outdoor use:** installation Class 3
10	Electrostatic Discharge[a] with a Severity Level of 3 having contact discharge at 6 kV to accessible metal parts and Air discharge at 8 kV to accessible parts of insulating material
[a] The noted factors are exempt from being considered when requirements from Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991, are applied	

14.2.9 Three-phase motors shall be protected by:

a) Three properly rated overcurrent units, each complying with the applicable requirements of 14.2.5 through 14.2.8; or

b) Thermal protectors, combination of thermal protectors and overcurrent devices, or equivalent methods of protection may be employed where the specific protective arrangement has been investigated and found to provide proper protection under primary single-phase failure conditions when supplied from transformers connected wye-delta or delta-wye. Assemblies so investigated shall be marked to indicate that the motor is protected under primary single-phase conditions. This marking may be a paper sticker, decal, or an attached wiring diagram.

15 Overcurrent Protection of High-Voltage Control-Circuit Conductors

15.1 General

15.1.1 For the purpose of the requirements in 15.2.1 – 15.4.2, a control circuit is one that carries electric signals to operate a controller that, in turn, governs power delivered to a motor or other load in the product. A control circuit does not carry main-power current. If a control circuit is supplied through a transformer provided as part of the product, see Overcurrent Protection of Transformers, Section 14, for additional requirements.

15.2 Direct-connected high-voltage control circuit

15.2.1 For the purpose of these requirements, a direct-connected high-voltage control circuit is one that is supplied from a branch circuit separate from a branch circuit that supplies other loads within the product. It is not tapped from the load side of the overcurrent device or devices of the controlled circuit or circuits within the product. See 77.11.

15.3 Tapped high-voltage control circuits

15.3.1 For the purpose of these requirements, a tapped high-voltage control circuit is a circuit that is tapped within the burner on the load side of the overcurrent device or devices for the controlled load. Such a circuit shall be protected in accordance with 15.3.3 – 15.4.2.

15.3.2 A high-voltage control circuit that is tapped from the main power circuit at a point outside of the control equipment enclosure shall be protected as specified in Column A of Table 430-72(b) of the National Electrical Code, NFPA 70.

15.3.3 A tapped high-voltage control-circuit conductor shall be provided with overcurrent protection. The rating of the overcurrent-protective device shall not exceed the value specified in Table 15.1.

Exception No. 1: A 18, 16, or 14 AWG (0.82, 1.3, or 2.1 mm^2) conductor that is not more than 4 feet (1.2 m) long between points of opposite polarity may be protected by a fuse or an HACR Type circuit breaker rated 60 amperes or less.

Exception No. 2: An overcurrent-protective device of a higher rating may be used if the conductors withstand short-circuiting when tested as specified in 61.9.

Exception No. 3: A lead that is not more than 12 inches (305 mm) long need not be provided with overcurrent protection.

Exception No. 4: A control-circuit conductor, supplied from the secondary of a single-phase transformer that is connected so that only a 2-wire (single voltage) secondary is used, may be protected by an overcurrent device located in the primary side of the transformer if:

a) This protection is in accordance with the requirements specified in Overcurrent Protection of Transformers, Section 14, and

b) The rating of the device does not exceed the applicable value specified in Table 15.1 multiplied by the ratio of secondary-to-primary rated transformer voltage.

Table 15.1
Overcurrent protective device rating for control circuit conductors

Tapped control-circuit conductor, size,		Minimum rating of overcurrent protective device, amperes			
		Conductors contained in control equipment enclosure		Conductors extending beyond control-equipment enclosure	
AWG	(mm^2)	Copper	Aluminum[a]	Copper	Aluminum[a]
18	(0.82)	25	–	7	–
16	(1.3)	40	–	10	–
14	(2.1)	100	–	45	–
12	(3.3)	120	100	60	45
10	(5.3)	160	140	90	75
Larger than 10		b	b	c	c

[a] Includes copper-clad aluminum.

[b] 400 percent of value specified for 60°C conductors in Table 310-17 of National Electrical Code, ANSI/NFPA 70.

[c] 300 percent of value specified for 60°C conductors in Table 310-16 of National Electrical Code, ANSI/NFPA 70.

15.4 Overcurrent-protective devices

15.4.1 Overcurrent protection for a tapped high-voltage control-circuit conductor, as required by 15.3.3, shall be provided as part of the product. If a fuse is used, the product shall be marked in accordance with 77.9.

Exception: The overcurrent device or devices need not be provided as part of the product if, based on the marked rating of the product, the rating of the branch-circuit overcurrent-protective device or devices does not exceed the values specified in Table 15.1.

15.4.2 A control-circuit overcurrent-protective device shall:

a) Be provided for all ungrounded conductors;

b) Be of a size in accordance with the requirements in 15.3.3; and

c) Have a voltage rating not less than the circuit in which it is used.

The device shall be a circuit breaker or a fuse that is acceptable for branch-circuit protection. Examples of an acceptable fuse are a Class CC, G, H, J, K, L, or R cartridge fuse and a Type S plug fuse.

Exception: If the control circuit is tapped from a circuit supplying other loads in the product, a device used for overcurrent protection may be of the supplementary type provided it has a short-circuit rating acceptable for the circuit in which it is used. See Table 61.1. If the supplementary device used is a fuse, the product shall be marked in accordance with 77.10.

16 Overcurrent Protection of Transformers

16.1 High-voltage transformers – General

16.1.1 A transformer, other than as described in 16.4.1 and 16.4.2, is considered to be a high-voltage transformer and shall:

a) Be provided with thermal-overload protection in accordance with the requirements in 16.2.1; or

b) Be protected by an overcurrent device or devices in accordance with the requirements in 16.3.1; or

Exception No. 1: This requirement is not applicable to an interchangeable ignition transformer that has been investigated in accordance with the requirements for ignition transformers in the Standard for Specialty Transformers, UL 506.

Exception No. 2: This requirement is not applicable to high voltage transformers complying with the requirements in the Burnout Test, High-Voltage Transformers, Section 55 of the Standard for Commercial-Industrial Gas Burners, UL 295.

16.2 High-voltage transformers – Thermal protection

16.2.1 If a high-voltage transformer is provided with a thermal-overload-protective device, the device shall be arranged to interrupt primary current and shall limit temperatures of the transformer windings under overload conditions to those acceptable for the class of insulation employed in the windings. See Overload Test, High Voltage Transformers, Section 62.

Exception: If the thermal-overload-protective device provided is a nonrenewable thermal cutoff, a burnout test is to be conducted in place of the overload test. See Burnout Test, High-Voltage Transformers, Section 63.

16.2.2 A thermal cutoff shall comply with the requirements in the Standard for Thermal-Links – Requirements and Application Guide, UL 60691. A manually or automatically reset thermal protector shall have an endurance rating of not less than 6000 cycles and shall comply with the requirements for calibration of temperature-limiting controls in the Standard for Temperature-Indicating and -Regulating Equipment, UL 873. Compliance with the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills these requirements.

16.3 High-voltage transformers – Overcurrent protection

16.3.1 Each overcurrent device that protects a high-voltage transformer shall comply with the requirements specified in 16.3.2, 16.3.3 and 16.5.1 – 16.5.3.

16.3.2 A high-voltage transformer shall be protected by an overcurrent device, or devices, that is located in the primary circuit and that is rated or set as indicated in Table 16.1 for the primary. See 16.3.3 and 16.5.1.

Table 16.1
Maximum rating of transformer overcurrent protective device

Rated primary or secondary current, amperes	Maximum rating of overcurrent device, percent of transformer current rating, when in:	
	Primary	Secondary
Less than 2	300[a]	167
2 or more, less than 9	167	167
9 or more	125[b]	125[b]

[a] Does not apply to an autotransformer; may be increased to 500 percent if transformer supplies a motor control circuit.

[b] If 125 percent of the current does not correspond to the standard rating of fuse or circuit breaker, the next highest standard rating may be used. For the purpose of this requirement, standard ratings are 1, 3, 6, 10, 15, 20, 25, 30, 35, 40, 45, 50, and 60 amperes.

16.3.3 If the circuit supplying a transformer is provided with overcurrent protection rated or set at not more than 250 percent of the rated primary current of the transformer, additional overcurrent protection is not required in the primary circuit provided the secondary circuit is protected by a protective device rated or set as indicated in Table 16.1 for the secondary.

16.4 Low-voltage transformers – General

16.4.1 Except as specified in 16.4.2, a transformer having a rated output of not more than 30 volts and 1000 volt-amperes (Class 1, power-limited circuit) shall be protected by an overcurrent device, or devices, located in the primary circuit. The overcurrent device, or devices, shall be rated or set at not more than 167 percent of the primary current rating of the transformer. See 16.5.1.

16.4.2 A transformer that directly supplies a Class 2 circuit shall, in accordance with the requirements in the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1 and the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3, either limit the output current (inherently-limiting transformer) or be equipped with an overcurrent device, or devices (noninherently-limiting transformer).

16.5 Low-voltage transformers – Overcurrent protective devices

16.5.1 Overcurrent protection in the primary circuit of a transformer, as described in 16.3.2 and 16.4.1, need not be provided as part of the product if, based on the marked rating of the product, the rating of the branch-circuit overcurrent-protective device, or devices, does not exceed the values specified in 16.3.2 or 16.4.1, as applicable.

16.5.2 Overcurrent protection in the secondary circuit of a transformer, as required by 16.3.3 shall be provided as part of the appliance. If a fuse is used, the appliance shall be marked in accordance with 77.9.

16.5.3 A required transformer overcurrent-protective device provided as part of the product shall:

a) Be provided for all ungrounded conductors;

b) Be of a size in accordance with the requirements in 16.3.2 – 16.4.1, as applicable;

c) Have a voltage rating not less than the circuit in which it is used.

The device shall be a circuit breaker, or a fuse, that is acceptable for branch-circuit protection. Examples of an acceptable fuse are a Class CC, G, H, J, K, L, or R cartridge fuse and a Type S plug fuse.

Exception: If a transformer supply is tapped from a circuit supplying other loads in the product, a fuse used for overcurrent protection may be of the supplementary type provided that the fuse has a short-circuit rating acceptable for the circuit in which it is used. See Table 61.1. The product shall be marked in accordance with 77.10.

17 Switches and Controllers

17.1 A controller(s) for controlling the loads involved shall be provided for all assemblies incorporating more than one motor intended for connection to the same power supply.

Exception: A controller (s) for controlling the loads involved shall be provided for all assemblies incorporating more than one motor intended for connection to the same power supply.

17.2 Motor controllers shall be arranged so that they will simultaneously open a sufficient number of ungrounded conductors to interrupt current flow to the motor.

17.3 A single controller may control more than one motor if the controller is rated for the combined load controlled. The assembly shall be marked in accordance with 77.12 if the same controller contacts handle a remote motor(s) in addition to the motor(s) in the unit containing the controller.

17.4 A controller or switch shall be rated for the load that it controls. The load controlled is to include any load external to the assembly for which connections in the controller or switch circuit are provided.

17.5 A controller that may be called upon to break a motor load under locked-rotor conditions shall have a current-interrupting capacity not less than the locked-rotor load of the motor controlled.

17.6 If the controller is cycled by the operation of an automatic-reset overload device, it is to withstand an endurance test under locked-rotor conditions without malfunction. The endurance test is to be of a duration equivalent to that required for the overload device and at an equivalent rate.

17.7 The locked-rotor load of a motor is based on six times the full-load current rating of the motor if alternating current, and ten times the full-load current rating if direct current.

17.8 If the marked maximum fuse size of the appliance assembly does not exceed the maximum size for protecting the motor of the smallest rating, two or more motors each having individual running overcurrent protection may be connected to the same power supply if it can be determined that a fuse of the marked size will not open under the most severe conditions of service that might be encountered.

18 Capacitors

18.1 A motor starting or running capacitor shall be housed within an enclosure or container that will protect the plates against mechanical damage and that will prevent the emission of flame or molten material resulting from malfunction of the capacitor. Except as noted in 18.2 and 18.3, the container shall be of metal providing strength and protection not less than that of uncoated steel 0.020 inch (0.51 mm) thick.

18.2 The individual container of a capacitor may be of material other than metal if the capacitor is mounted in an enclosure that houses other parts of the device assembly, and provided that such box, case, or the like, is acceptable for the enclosure of current-carrying parts.

18.3 If the container of an electrolytic capacitor is constructed of metal, it shall be insulated from dead metal parts.

18.4 A capacitor employing a liquid dielectric medium more combustible than askarel shall be protected against expulsion of the dielectric medium when tested in accordance with the applicable performance requirements of this standard, including faulted overcurrent conditions based on the circuit in which it is used. See Short-Circuit Test, Section 61.

Exception: If the available fault current is limited by other components in the circuit, such as a motor start winding, the capacitor may be tested using a fault current less than the test current specified in Table 61.1, but not less than the current established by dividing the circuit voltage by the impedance of the other component(s).

19 Electrical Insulating Materials

19.1 Material for the mounting of current-carrying parts shall be porcelain, phenolic composition, cold-molded composition, or equivalent material.

19.2 Ordinary vulcanized fiber may be used for insulating bushings, washers, separators, and barriers, but not as the sole support for uninsulated live parts where shrinkage, current leakage, or warpage may introduce a risk of fire or electric shock.

19.3 An insulating liner or barrier of vulcanized fiber, varnished cloth, mica, phenolic composition, or similar material employed where spacings would otherwise be insufficient, shall be not less than 0.028 inch (0.71 mm) in thickness, except that a liner or barrier not less than 0.013 inch (0.33 mm) in thickness may be used in conjunction with an air spacing of not less than one-half of the through air spacing required. The liner shall be located so that it will not be damaged by arcing. Material having a lesser thickness may be used if it has equivalent insulating, mechanical, and flammability properties.

20 High-Voltage Circuits

20.1 Except as noted in 20.2 – 20.4, the spacings between uninsulated live parts of opposite polarity and between an uninsulated live part and a dead metal part shall be not less than the values indicated in Table 20.1.

Table 20.1
Minimum spacings

Ratings		Minimum spacings[a], inch (mm)					
Volt-amperes	Volts	Through air		Over surface		To enclosure[d]	
0 – 2000	0 – 300[b]	1/8[c]	(3.2)	1/4	(6.4)	1/4	(6.4)
more than 2000	0 – 150	1/8[c]	(3.2)	1/4	(6.4)	1/2[e]	(12.7)
	151 – 300	1/4	(6.4)	3/8	(9.5)	1/2[e]	(12.7)
	301 – 600	3/8	(9.5)	1/2[d,e]	(12.7)	1/2[e]	(12.7)

[a] See 19.3.

[b] If over 300 volts, spacings in last line of table apply.

[c] The spacings between wiring terminals of opposite polarity, or between a wiring terminal and grounded metal, shall not be less than 1/4 inch (6.4 mm), except that if short-circuiting or grounding of such terminals will not result from projecting strands of wire, the spacing need not be greater than that given in the above table. Wiring terminals are those connected to the field and not factory wired. Measurements are to be made with solid wire of adequate ampacity for the load connected to each terminal.

[d] Includes fittings for conduit or metal-clad cable.

[e] The spacings at wiring terminals of a motor shall be at least 1/4 inch (6.4 mm) for a motor rated 250 volts or less and 3/8 inch (9.5 mm) for a motor rated more than 250 volts.

20.2 The through-air and over-surface spacings at an individual component part are to be judged on the basis of the total volt-ampere consumption of the load(s) that the component controls. However, the spacing from the component to the enclosure shall be judged on the basis of the total load on all components in the enclosure. For example, the through-air and over surface spacings at a component which controls only a motor is judged on the basis of the volt-ampere of the motor. A component that controls loads in addition to the motor is similarly judged on the basis of the sum of the volt-ampere of the loads so controlled; however, a component that independently controls separate loads is judged on the basis of the volt-ampere of the larger load. The volt-ampere values for the load referred to above are to be determined by the measured input.

20.3 The spacing requirements in Table 20.1 do not apply to the inherent spacings of a component which is judged on the basis of the requirements for the component. However, the electrical clearance resulting from the installation of a component, including clearances to dead metal or enclosures, shall be those indicated.

20.4 All uninsulated live parts connected to different circuits, except subdivided or branch circuits of the same voltage from the same feeder, shall be spaced from one another as though they were parts of opposite polarity in accordance with the requirements indicated in 20.1 – 20.3 and shall be judged on the basis of the highest voltage involved.

20.5 For circuits not exceeding 300 volts, the over-surface spacings for glass-insulated terminals of motors may be 1/8 inch (3.2 mm) where 1/4 inch (6.4 mm) is specified in the table; and may be 1/4 inch where 3/8 inch (9.5 mm) is specified.

21 Low-Voltage Circuits

21.1 The spacings for low-voltage electrical components that are installed in a circuit that includes a motor overload protective device, or other protective device, where a short or grounded circuit may result in a risk of fire, electric shock, or injury to persons shall comply with 21.2 – 21.4.

21.2 The spacing between an uninsulated live part and the wall of a metal enclosure including fittings for the connection of conduit or metal-clad cable shall be not less than 1/8 inch (3.2 mm). See 20.4.

21.3 The spacing between wiring terminals regardless of polarity, and between the wiring terminal and a dead metal part (including the enclosure and fittings for the connection of conduit) which may be grounded when the device is installed shall be not less than 1/4 inch (6.4 mm).

21.4 The spacing between uninsulated live parts, regardless of polarity, and between an insulated live part and a dead metal part, other than the enclosure, which may be grounded when the device is installed shall be not less than 1/32 inch (0.8 mm), provided that the construction of the parts is such that spacings will be definitely maintained.

21.5 The spacings in low-voltage circuits that do not contain devices such as indicated in 21.1 are not specified.

CONSTRUCTION – MECHANICAL

22 General

22.1 The requirements of Section 8, Enclosures, are not applicable to mechanical service functions which are not normally performed with the incinerator energized.

22.2 Moving parts such as fan blades, blower wheels, pulleys, belts, etc., which may cause injury shall be enclosed or guarded.

22.3 If the removal of doors or panels or shields will expose such moving parts:

a) The opening or removal of the door, panel or shield shall require the use of tools; or

b) An interlocking device shall shut off the mechanism; or

c) A warning marking shall be displayed which reads essentially as follows:

DANGER – To Avoid Injury From Moving Parts, Shut Off The (Incinerator) Before (Removing-Opening) This (Cover-Door).

22.4 The distance from an opening in a required guard or enclosure to the moving part mentioned in 22.3 shall be in accordance with the following table, but the minor dimension of the opening shall not in any case exceed 3 inches (76.2 mm). For an opening having a minor dimension intermediate between two of

the values included in the table, the distance from the opening to the moving part shall be not less than that found by appropriate interpolation between the corresponding values in the right hand column of the table. The minor dimension of the opening is determined by the largest hemispherically tipped cylindrical probe that can be inserted through the opening with a force of 5 pounds.

Minor dimensions of opening, inches[a]	Minimum distance from opening to moving part, inches
1/4	1/2
3/8	1-1/2
1/2	2-1/2
3/4	4-1/2
1	6-1/2
1-1/2	10-1/2
2	14-1/2
Over 2	30

[a] Openings less than 1/4 inch are not to be considered.

22.5 A moving part is not to be considered when judging compliance with 22.3 and 22.4 if the part is unlikely to be contacted through the opening because of fixed components, including baffles.

22.6 Parts that may come in contact with the operator's hand during normal adjustment or servicing shall be free from sharp projections or edges and projecting screw ends.

22.7 Parts that are subjected to pressure during operation shall be constructed to withstand, without bursting, a hydrostatic pressure equivalent to five times the maximum pressure to which they may be subjected. See Hydrostatic Strength – Test No. 17, Section 66.

22.8 An uninsulated high-voltage live part and a moving part that may involve a risk of injury to persons shall be located, guarded, or enclosed so as to reduce the likelihood of unintentional contact by personnel performing service functions that may have to be performed with the equipment energized.

Exception: A moving part is not required to comply with 22.8 if the part is unlikely to be contacted through the opening because of fixed components, including baffles.

22.9 Service functions which may have to be performed with the equipment energized include:

a) Adjusting the setting of temperature controls with or without marked dial settings;

b) Resetting control trip mechanism;

c) Operating manual switches; or

d) Adjusting air-flow dampers.

A factory set and sealed control is not considered to be adjustable.

22.10 The requirements of 22.8 are not applicable to mechanical service functions which are not normally performed with the equipment energized.

22.11 Adjustable or resettable electrical control or manual switching devices may be located or oriented with respect to uninsulated live parts, so that manipulation of the mechanism for adjustment, resetting, or

operation can be accomplished in the normal direction of access if uninsulated live parts or moving parts that may involve a risk of injury to persons are:

a) Not located in front, in the direction of access, of the mechanism; and

b) Are not located within 6 inches (152 mm) on any side or behind the mechanism, unless guarded.

22.12 An electrical control component that may require examination, adjustment, servicing, or maintenance while energized, not including voltage measurements, shall be located and mounted with respect to other components and grounded metal parts so that it is accessible for electrical service functions without subjecting the serviceman to a risk of electric shock from adjacent uninsulated live parts or to unintentional contact from adjacent moving parts that may involve a risk of injury to persons.

22.13 Accessibility and protection from a risk of fire, electric shock, or injury to persons may be obtained by mounting the control components in an assembly so that unimpeded access is provided to each component through the access cover or panel in the outer cabinet and the cover of the control assembly enclosure with the following arrangement:

a) The components are located with respect to the access opening in the cabinet so that the farthest component in the control assembly is not more than 14 inches (356 mm) from the plane of the access opening.

b) Uninsulated live parts outside the control assembly projected clear space (except for live parts within a control panel) or unguarded moving parts that may involve a risk of injury to persons are located not closer than 6 inches (152 mm) from any side of the access area. The projected clear space is considered to be bounded on the sides by the projection of the smallest rectangular perimeter surrounding the outside edge of the components or control enclosure when provided. The access area is considered to be bounded on the sides by the projection of the perimeter of the access opening in the outer cabinet to the closest rectangular perimeter surrounding the outside edge of the component or control enclosure.

c) The volume generated by the projected clear space of the control assembly to the access opening in the outer cabinet (within the access area is completely free of obstructions, including wiring.

d) Access to the components in the control assembly is not impeded in the direction of access by other components or by wiring in this assembly.

e) Extractor-type fuseholders and snap switches mounted through the control assembly enclosure are to be located so that:

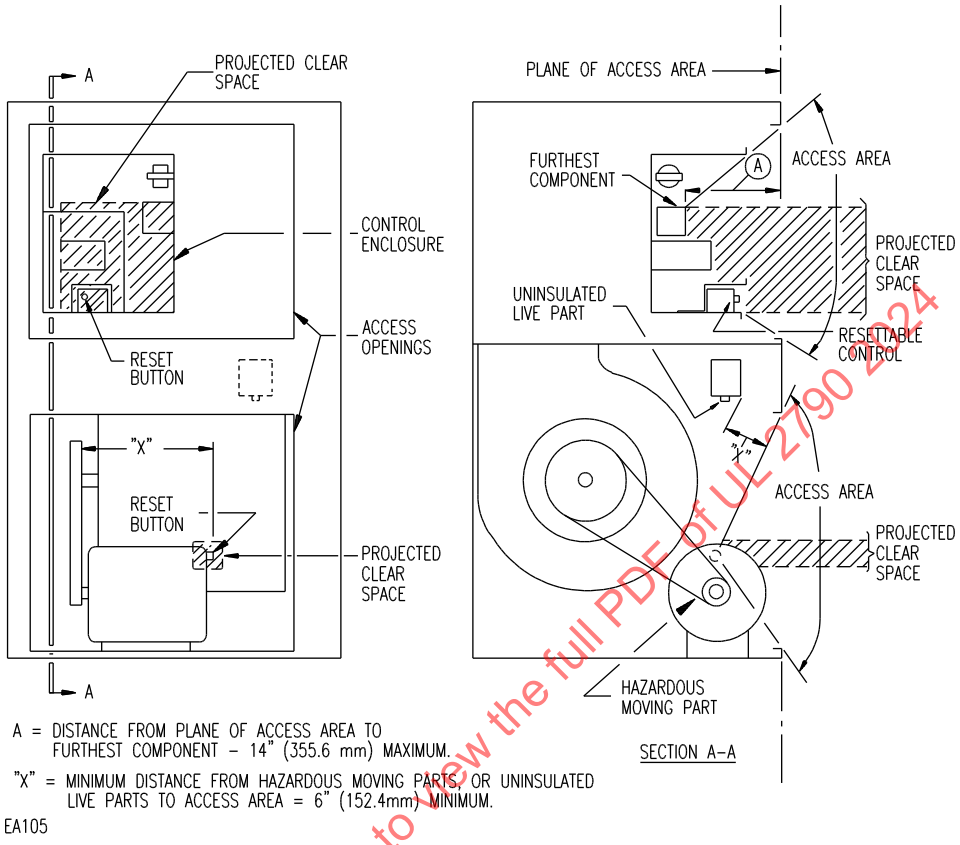
1) There is unimpeded access to these components through the access opening in the outer cabinet; and

2) They are not immediately adjacent to uninsulated live parts outside the control assembly enclosure, unless guarded.

Also see Figure 22.1.

Figure 22.1

Accessibility and protection



A = DISTANCE FROM PLANE OF ACCESS AREA TO FURTHEST COMPONENT – 14" (355.6 mm) MAXIMUM.

"X" = MINIMUM DISTANCE FROM HAZARDOUS MOVING PARTS, OR UNINSULATED LIVE PARTS TO ACCESS AREA = 6" (152.4mm) MINIMUM.

EA105

22.14 Components in a low-voltage circuit shall comply with the requirements of 22.12 in their relation to uninsulated live parts in a high-voltage circuit and to hazardous moving parts.

22.15 The following are not considered to be uninsulated live parts:

a) Coils of controllers;

b) Relays and solenoids;

c) Transformer windings, if the coils and windings are provided with insulating overwraps;

d) Enclosed motor windings;

e) Insulated terminals and splices; and

f) Insulated wires.

22.16 Moving parts such as fan blades, blower wheels, pulleys, belts, and the like, which may cause injury shall be enclosed or guarded. If the removal of doors, panels or shields will expose such moving parts:

a) The opening or removal of the door, panel or shield shall require the use of tools; or

b) An interlocking device shall shut off the mechanism; or

c) The door, panel, or shield shall be marked in accordance with 77.23.

Exception: A moving part is not required to comply with 22.16 if the part is unlikely to be contacted through the opening because of fixed components, including baffles.

22.17 The distance from an opening in a required guard or enclosure to the moving part mentioned in 22.16 shall be in accordance with Table 22.1, but the minor dimension of the opening shall not in any case exceed 3 inches (76.2 mm). For an opening having a minor dimension intermediate between two of the values included in the table, the distance from the opening to the moving part shall be not less than that found by appropriate interpolation between the corresponding values in the right-hand column of the table. The minor dimension of the opening is determined by the largest hemispherically tipped cylindrical probe that can be inserted through the opening with a force of 5 pounds (22 N).

Table 22.1
Dimensions of openings

Minor dimensions of opening,		Minimum distance from opening to moving part,	
inches[a]	(mm)	inches[a]	(mm)
1/4	(6.4)	1/2	(12.7)
3/8	(9.5)	1-1/2	(38.1)
1/2	(12.7)	2-1/2	(63.5)
3/4	(19.1)	4-1/2	(114)
1	(25.4)	6-1/2	(165)
1	(25.4)	6-1/2	(165)
1	(25.4)	6-1/2	(165)
1-1/2	(38.1)	10-1/2	(267)

Table 22.1 Continued on Next Page

Table 22.1 Continued

Minor dimensions of opening,		Minimum distance from opening to moving part,	
inches[a]	(mm)	inches[a]	(mm)
2	(50.8)	14-1/2	(369)
over 2	(over 50.8)	30	(762)
[a] Openings less than 1/4 inch (6.4 mm) are not to be considered.			

23 Corrosion Protection

23.1 Iron and steel parts shall be protected against corrosion by painting, galvanizing, plating or other equivalent means when malfunctioning of such unprotected part results in a hazardous condition.

Exception: Cast-iron parts, cast-aluminum parts and ASME coded pressure vessels are not required to be protected against corrosion.

23.2 Surfaces of the burner assembly and flue gas conveying parts that contact flue gas condensation shall be evaluated with respect to resistance to corrosion. Among the factors to be considered are material thickness and type, length of time subjected to the condensate condition and type of corrosion protection provided. See 46.3.

24 Fuel Confining Parts

24.1 Fuel confining parts, or operating parts if failure of the part will allow excess leakage of fuel, unintended operation, or restrict a safety device or control from functioning, shall be of sufficient strength, durability, and resistance to fire. Such parts shall be made of material having a melting point (solidus temperature) of not less than 950°F (510°C) and a tensile strength of not less than 10,000 psi at 400°F (204°C). Such parts shall not sag, distort, melt, oxidize, or show leakage of fuel during any of the tests specified herein.

24.2 Soft solder shall not be used on any fuel-handling parts if melting of the solder may allow leakage of fuel. Soft-soldered joints, where permitted, shall be made mechanically secure before soldering.

24.3 The burner shall function so as to reduce to a minimum the generation of unburned vapors, and shall not include chambers or pockets in which unburned vapors may accumulate.

24.4 Fuel piping and fuel handling components shall not be enclosed within an unventilated cabinet, or other such construction.

CONSTRUCTION – INCINERATOR ASSEMBLY

25 General

25.1 Each incinerator shall be factory built to include all the components necessary for its normal function when installed as intended. It may be furnished as separate components, one component consisting of the burner assembly, one component consisting of the combustion air blower assembly, and the other consisting of the incinerator.

25.2 An incinerator, if not manufactured as an assembly, shall consist of as few subassemblies as practicable. Each subassembly shall be capable of being incorporated into the final assembly without requiring alteration, cutting, drilling, threading, welding or similar tasks by the installer. Two or more subassemblies, which must bear a definite relationship to each other for the proper and safe operation of

the incinerator, shall be designed and marked so that they may readily be incorporated into the final assembly in their correct relationship.

25.3 A radiation shield or baffle employed to reduce the risk of unintended temperatures shall be assembled as part of the incinerator; or be part of a subassembly that must be attached to the incinerator for its normal operation; or be designed so that the incinerator cannot be assembled for operation without first attaching the required shield or baffle in its proper position.

25.4 Each incinerator shall afford convenient operation by the user of those parts requiring attention or manipulation by him in normal usage.

25.5 Any adjustable part shall be provided with a locking device.

25.6 Openings in perforated or expanded metal panels, provided over combustion air or vent-relief openings shall not be less than 1.8 inch (45.7 mm) diameter. If the openings in such panels are other than circular in shape, they shall be of such size that will permit entrance of a No. 20 drill.

25.7 The various parts shall be constructed and assembled in accordance with these requirements in a manner to insure strength, rigidity, and durability.

25.8 Parts of an incinerator shall not crack, warp, or sustain other damage likely to permit passage of flame or emission of gases or sparks to the exterior when tested in accordance with these requirements.

25.9 An incinerator shall be constructed to avoid the fouling or clogging of an ignition assembly by ashes or drippings.

25.10 An incinerator shall be designed to prevent flames, sparks, gases, burning particles, or drippings being expelled into the room.

25.11 An incinerator shall be so constructed that glowing or heated particles cannot fall to the floor even when the ash pan is removed.

26 Accessibility

26.1 All flue gas passageways or heating surfaces of gas-fired incinerators shall be accessible for inspection and cleaning without major dismantling and without removal of controls.

26.2 Provision shall be made for observation of each pilot and main burner flame during adjustment and under operating conditions.

26.3 Sufficient and reasonable accessibility shall be afforded for cleaning, inspection, repair, and replacement of all burners, controls, and safety devices when the incinerator is installed as recommended by the manufacturer. The arrangement of parts in an assembly removed for normal care shall be such that their restoration, following removal, will not necessitate realignment to secure their proper relationship with other parts of the assembly. Special tools that may be required for normal care to be done by the operator shall be supplied with the incinerator.

26.4 Heads and nuts of bolts which must be removed to permit the removal of cleanout plates shall not be placed where they will be in contact with flue gases.

27 Baffles

27.1 Flue baffles shall be removable for cleaning or shall be designed so that they cannot be dislodged or distorted during cleaning. Flue baffles which are removable for cleaning shall be designed so as to assure their replacement in the correct position.

28 Temperature Controls

28.1 An incinerator shall be provided with a temperature control to achieve and regulate the required temperature to incinerate the applicable contents, per manufacturer's instructions.

28.2 The control shall function to regulate the fuel input by opening an electrical circuit and be arranged to effect the direct opening of that circuit, whether the switching mechanism is integral with or remote from the sensing element. The burner operation can be resumed automatically when the outlet air temperature decreases below the limits specified in set point.

28.3 The purpose of the requirement in 28.2 is to avoid interposing in the control circuit with other controls, the failure of which may result in a condition that the temperature control is intended to prevent. Additional testing of configurations of the temperature control in conjunction with other controls is left to the discretion of the testing agency.

29 Bases

29.1 The base of an incinerator shall be constructed to support the incinerator as intended.

29.2 The base of an incinerator shall be constructed of metal or fabricated of other noncombustible material in a manner to provide equivalent strength and durability. The assembly shall be constructed so that there will be no open passages.

29.3 The casing of an incinerator for installation on combustible flooring shall completely close the bottom or be constructed to provide a solid partition below the combustion-chamber ash compartment assembly. The ash compartment assembly is considered to include the floor of the ash compartment.

30 Incinerator Combustion Chambers

30.1 Combustion chambers shall be constructed of cast iron, sheet steel, or other material determined to comply with this requirement. The temperature of the metal shall not exceed the limits specified in Table 60.1, when the incinerator is operated under the conditions of the applicable tests in the Temperature Tests, Section 60. Sheet steel, if used, shall maintain strength, rigidity, durability, resistance to corrosion, and other physical properties equivalent to AISI 1010 hot rolled sheet steel having a minimum thickness of 0.053 inch (1.3 mm).

30.2 Joints in the combustion chamber shall be welded, brazed, or be made by a machined slip joint, or by machining, bolting or riveting. A joint shall not depend primarily on cement for tightness. A slip or lap joint shall not depend solely upon friction of the joint itself for strength.

30.3 Combustion-chamber (fire-box) lining, if used, shall be durable, securely held in place, and accessible for replacement with equivalent material.

31 Ash Compartment

31.1 An incinerator may be provided with a removable ash pan which having capacity of not less than 20 percent of the volume capacity of the incinerator combustion chamber.

31.2 The door of an ash compartment shall be self-closing or the incinerator shall be tested in accordance with these requirements with the closing means or door in the open position.

32 Radiation Shields

32.1 A radiation shield or liner shall be so constructed, formed, and supported to maintain its intended positioning and to resist distortion or sagging in service. A shield or liner shall be protected against corrosion if its deterioration may cause temperatures in excess of those specified in Table 60.1 when the product is tested as specified in Temperature Test No. 10, Section 59. Any finish to obtain the required resistance to corrosion shall not be damaged by heat when the incinerator is tested as specified in the Temperature Test No. 10, Section 59.

33 Casings

33.1 An outer casing or jacket shall be made of steel or other suitable material, reinforced or formed if necessary, so that it is not likely to be damaged through handling in shipment, installation, and use. Sheet metal casings shall be made of steel having a minimum thickness of 0.0254 inch (0.645 mm), and all surfaces shall be protected against corrosion.

33.2 Sheet iron or steel, used for casings to confine circulating air shall not be less than 0.032 inch (0.813 mm) thick.

33.3 Access panels as need be removed for normal service and accessibility shall be designed to permit ready removal and replacement repeatedly without causing damage or impairing any required insulating value.

33.4 A removable panel through which air is drawn for combustion shall be so designed as to restrain it from being attached in a manner that may cause improper performance of the incinerator.

33.5 A removable panel shall be so constructed that it will not be interchangeable with other panels on the same incinerator when interchange may allow improper operation of the incinerator.

33.6 The casing of a incinerator shall completely close the bottom or be constructed to provide an effective radiation barrier between the heat exchanger and the floor; except an opening intended to be always connected to a circulating air-distribution duct may be permitted.

33.7 Connection between the heat exchanger and the casing which encloses circulating air shall be constructed to reduce the risk of combustion products leaking into the ambient air.

34 Flue Collars

34.1 A flue collar shall be made of material not lighter than that designated for heating surfaces. Such collars shall extend through the casing externally a sufficient distance to permit secure attachment of the vent connector.

35 Chimneys

Reprinted with permission from NFPA 82-2004: Standard on Incinerators and Waste and Linen Handling Systems and Equipment, Copyright © 2004, National Fire Protection Association, Quincy, MA 02169.

35.1 The chimney shall serve only the incinerator.

35.2 If incinerator walls or the roof of the combustion chamber support the chimney, they shall be built to support the load imposed.

35.3 A factory-built chimney shall be permitted to be supported at intervals by the building structure, in which case expansion joints shall be provided at each support level. All joints shall be liquidtight or of a design such that liquid will drain to the interior of the chimney.

35.4 Cleanout openings, if provided, shall be equipped with ferrous metal doors and frames arranged to remain tightly closed when not in use. A clearance of not less than 914 mm (36 in.) shall be provided between cleanout doors and combustible material.

35.5 Breachings shall be designed or otherwise protected in an approved manner, such as by guard rails or shields, to protect personnel from accidental contact with surfaces that exceed 160°F (71.1°C).

35.6 External insulation shall not be used on hot breachings.

35.7 Breachings that utilize listed medium-heat chimney sections shall be permitted, provided these sections are joined together with continuous welds, flanges, or couplings.

35.8 Chimney connectors or breaching up to 457 mm (18 in.) in diameter or greatest cross-section dimension shall be lined with not less than 63.5 mm (2-1/2 in.) high-duty, spall-resistant refractory brick (as defined in ASTM C 27).

35.9 Chimney connectors or breaching over 457 mm (18 in.) in diameter or greatest cross-section dimension shall be lined with not less than 114 mm (4-1/2 in.) of high-duty, spall-resistant refractory brick (as defined in ASTM C 27).

35.10 Castable plastic refractories or other refractories shall be permitted to be used in lieu of firebrick, provided such refractory is of equivalent heat and corrosion resistance.

35.11 Liners made of castable plastic refractories shall be supported by anchors made of corrosion-resistant steel capable of supporting the refractory load at 727°C (1500°F).

35.12 The insulating value shall be such that temperatures at the supports shall not exceed 727°C (1500°F) under all firing conditions.

35.13 The net internal free area of the connector shall be not less than the free area of the flue collar of the incinerator.

35.14 A chimney connector shall not be enclosed.

35.15 The connector shall be readily accessible for inspection and replacement throughout its entire length.

35.16 Metal chimneys shall be properly riveted or welded, securely supported, and constructed in accordance with good engineering practice.

35.17 Metal chimneys shall be constructed of steel or cast iron. Sheet steel shall have a thickness not less than that indicated in Table 35.1.

35.18 Where secondary combustion temperatures do not exceed 982°C (1800°F), metal chimneys shall be lined with 114 mm (4-1/2 in.) of high-duty, spall-resistant firebrick (as defined in ASTM C 27, Standard Classification for Fireclay and High- Alumina Refractory Brick) laid in high-duty refractory mortar (as defined in ASTM C 199, Standard Test Method for Pier Test for Refractory Mortars).

35.19 The lining shall start at the base of the chimney and extend continuously to the top.

35.20 Equivalent linings of equivalent thickness, such as Class A or better alumina-silica base castable refractories or Class O or better insulating castable refractories, shall be permitted to be used.

35.21 Where secondary combustion temperatures exceed 982°C (1800°F), metal chimneys shall be lined with 114 mm (4-1/2 in.) of super-duty, spall-resistant refractory brick (as defined in ASTM C 27, Standard Classification for Fireclay and High-Alumina Refractory Brick) laid in refractory mortar.

35.22 The refractory mortar shall be high-duty for temperatures up to 1500°C (2730°F) and super-duty or better for temperatures up to 1600°C (2910°F).

Table 35.1
Minimum thickness of sheet steel chimneys[a]

Manufacturer standard U.S. gauge number	Minimum thickness		Area		Equivalent round diameter	
	in.	(mm)	in.^{2}	(mm^2)	in.	(mm)
16	0.054	(1.37)	Up to 154	(Up to 0.0994)	Up to 14	(Up to 356)
14	0.069	(1.75)	155 – 201	(0.0999 – 0.1296)	>14 – 16	(>356 – 406)
12	0.098	(2.49)	202 – 254	(0.1303 – 0.1638)	>16 – 18	(>406 – 457)
10	0.128	(3.25)	>254	(>0.1638)	>18	(>457)

[a]Regardless of minimum thicknesses in this table, the thickness of sheet metal shall be adequate to meet the requirements of 35.27.

35.23 Equivalent linings of equivalent thickness, such as Class B or better alumina-silica base castable refractories (as defined in ASTM C 27) in accordance with temperature requirements or Class P and Class Q insulating castable refractories (as defined in ASTM C 27) in accordance with temperature requirements, shall be permitted to be used.

35.24 Castable plastic refractories or other refractories shall be permitted to be used in metal chimneys in lieu of firebrick, provided such refractory is of equivalent heat and corrosion resistance.

35.25 Liners made of these refractories shall be supported by anchors made of corrosion-resistant steel capable of supporting the refractory load at 727°C (1500°F).

35.26 The insulating value shall be such that temperatures at the supports shall not exceed this temperature under all firing conditions.

35.27 Metal chimneys shall be properly riveted, welded, or bolted; securely supported; and constructed in accordance with good engineering practice as necessary to achieve the following conditions:

a) Strength to resist stresses due to steady or gusting wind loads;

b) Adequate anchoring, bracing, and inherent strength to withstand seismic and wind-induced vibrational stresses;

c) Proper material thickness for durability, considering fuel analysis, gas temperature, and exposure;

d) Security against leakage of flue gases under positive pressure

e) Allowance for thermal expansion of breaching and vertical sections

CONSTRUCTION – BURNER ASSEMBLIES

36 General

36.1 Each incinerator shall be factory built to include all the essential parts necessary for its normal function when installed as intended. The incinerator may be shipped as two or more subassemblies.

36.2 The various parts of an incinerator shall be constructed and assembled in accordance with these requirements in a manner to insure strength, rigidity, and durability.

36.3 The incinerator, if not manufactured as a unit assembly, shall consist of as few subassemblies as practicable. Except as indicated in 36.4, each subassembly shall be capable of being incorporated readily and correctly into the final assembly without requiring alteration, cutting, threading, welding, or similar tasks by the installer. Two or more subassemblies which must bear a definite relationship to each other for the intended operation of the incinerator shall be designed and marked so that they may readily be incorporated into the final assembly in their correct relationship.

36.4 Burner piping components such as the main automatic gas shutoff valve, main manual gas shutoff valve, pressure regulator, and the like, may be furnished as separate parts provided they can be joined in the field with standard piping. The standard piping may be furnished, cut, and threaded by the field installer.

36.5 An adjustable part shall be provided with a locking device.

36.6 Accessibility shall be afforded to all burner assembly parts, controls, and safety devices requiring normal care. The arrangement of parts in an assembly removed for normal care shall be such that their restoration following removal will not necessitate their realignment to secure their proper relationship with other parts of the assembly. Special tools that may be required for normal care to be done by the operator shall be supplied with the burner assembly.

36.7 The burner assembly or subassemblies shall incorporate provisions for support, adjustment, and attaching to the incinerator in order that installation can be made so as to restrain its twisting, sliding, or dropping out of the correct position.

36.8 A burner assembly of the swing type shall be provided with means for locking the burner in the firing position and to reduce the risk of it discharging fuel when in other than the firing position.

36.9 The base or frame on which burner parts are mounted shall be made of noncombustible material.

36.10 Bolt holes shall not intersect gasways unless provision is made to provide gas tightness.

36.11 Burner heads, mixer heads, and mixer tubes shall be of metals having a melting point, solidus temperature in excess of 1450°F (787.8°C).

36.12 A ribbon burner shall be so constructed that the ribbon assembly can be removed, cleaned, and replaced without the need for special tools.

36.13 The burner orifice and orifice holder shall be made of a material having a melting point, solidus temperature of not less than 1450°F (787.8°C) for use with manufactured and mixed gases and not less than 1100°F (593.3°C) for natural LP-Gas, and LP-Gas-air mixtures.

36.14 Main burner gas orifice spuds shall be threaded into their holders with at least 3-1/2 full threads.

36.15 A fan housing and an air duct shall be made of noncombustible material of sufficient strength and durability to resist damage during test under these requirements.

36.16 The exterior portion of a firing head within 6 inches (152 mm), measured parallel to its axis, from the firing end and all parts normally in contact with masonry, shall be made of iron or steel or suitable refractory. Interior parts shall be made of materials suitable for the purpose and, if considered fuel containing, shall conform to 24.1.

36.17 Flame spreaders and flame spreader supports used with upshot type burners shall be constructed so that they cannot be incorrectly fitted together, or they shall be marked to indicate the correct method of assembly. When it is necessary for service or assembly to remove the flame spreader. It shall not be threaded to its support unless the support is readily removable.

36.18 Flame spreader supports used with upshot type burners shall be so constructed that the flame spreader cannot be supported at other than the correct distance above the burner.

36.19 Burners shall be provided with means to reduce the risk of disintegrated ceramic flame spreader material falling into the burner port(s). They shall also be designed so that disintegration of the ceramic will not cause a hazardous change in the operating characteristics of the burner.

36.20 Joints in the pressure zone or in the burner head of a burner assembly, shall be gastight and shall not depend for mechanical strength nor primarily for tightness on cement or other sealing material, except where such joints form part of the port area. Joints shall be bolted, screwed, machined, welded, brazed or of equivalent construction.

37 Controls

37.1 All safety controls shall be readily accessible.

37.2 A safety control shall be supported in such a manner that it and its sensing element will remain in the intended position. It shall be possible to determine by observation or test that each control is in its intended location.

37.3 Nothing shall be provided for the purpose of permitting any safety control to be rendered ineffective or allowing firing of the burner assembly without the protection of all of the required safety controls.

37.4 A burner assembly not equipped to provide safe automatic restarting shall be arranged to require manual restart after any control functions to cause the fuel supply to be shut off and following restoration of an interrupted power supply.

37.5 The control system shall permit installation of a suitable limit control.

37.6 A safety control circuit shall be two-wire, one side grounded, having a nominal voltage of 120.

37.7 The above requirement does not apply to an isolated secondary circuit of a sensing device or a supervised circuit within a safety control or to the extension of such circuit to a separate element of the control, such as a flame sensing device.

37.8 A safety control or protective device switch shall interrupt the ungrounded conductors.

37.9 A control circuit shall be arranged so that it may be connected to a power supply branch circuit that can be protected against overcurrent at not more than the value appropriate for the rating of the electrical components included in the circuit.

37.10 A limit control which functions by opening a switch shall directly interrupt the power supply to the safety shutoff valve(s) except when two safety shutoff valves are used in the main burner supply line, see 44.1.1, one of the valves may be controlled through a contactor of a type that complies with the requirements for a use in a safety control circuit.

37.11 A burner circuit shall be arranged to reduce the risk of feedback by a motor capacitor, or similar device from energizing a fuel valve or ignition device.

37.12 Cabinet compartments housing gas piping and controls shall be ventilated.

38 Fan Housings and Air Tubes

38.1 A fan housing and an air duct shall be made of noncombustible material having the strength and durability to not be damaged during test under these requirements.

38.2 The exterior portion of a firing head within 6 inches (152 mm) measured parallel to its axis, from the firing end and all parts which may be in contact with masonry when the burner is installed as intended, shall be made of iron or steel. Interior parts shall be made of materials conforming with 24.1 – 24.4.

38.3 An outer shell of a blast tube or firing head, if made of sheet metal, shall be such as to assure strength, rigidity, durability, resistance to corrosion, and other physical properties equivalent to sheet steel having a thickness of not less than 0.053 inch (1.35 mm) or Type 309 stainless steel having a thickness of not less than 0.026 inch (0.66 mm).

39 Combustion Air Controls

39.1 An air shutter shall be capable of being adjusted readily to any desired setting and be provided with means for reducing the risk of a change in setting.

39.2 The air inlet shall be of sufficient area to supply adequate air for complete combustion under the specified draft condition and at the maximum rate of firing when the burner is installed as intended. All the air required for complete combustion shall be introduced in a manner which will assure thorough mixing of the fuel and air.

39.3 Introduction of secondary air necessary for combustion through checker-work in the floor of a combustion chamber is not permitted.

39.4 An air shutter shall provide for a reasonably smooth surface between the shutter and the matching face.

39.5 Sheet metal air shutters shall be of a thickness not less than 0.0254 inch (0.645 mm). If sheet metal air shutters are of a thickness less than 0.0508 inch (1.29 mm), they shall have the outer edges turned at right angles or be otherwise properly reinforced.

39.6 An air shutter shall by its design or assembly and selection of materials be guarded against sticking or corroding in position. Screws or bolts used for attaching or adjustment shall be of corrosion resistant material.

39.7 An adjustable part shall be guided to restrain its movement from its normal path during adjustment, and the means for adjusting the part shall be readily accessible.

39.8 A burner assembly, when adjusted according to the manufacturer's instructions furnished with the incinerator, shall maintain complete and stable combustion at all firing rates called for by the input and the air-gas ratio controls.

39.9 Linkage for operating air and fuel controls shall be designed to reliably maintain the correct fuel-air ratio and to resist accidental damage and disengagement.

39.10 A burner assembly equipped with a forced or induced draft fan, or both, shall be arranged to shut off the fuel supply immediately upon failure of the air supply. For a burner assembly having an input in excess of 2,500,000 Btu per hour the loss of combustion air shall result in safety shutdown so that a manual reset is required to restore the burner operation.

39.11 If air under pressure is mixed with the gas supply in a mixer and is automatically controlled, effective means shall be provided to restrain air from passing back into the gas line, or gas into the air supply. The gas and air supply shall be suitably controlled to restrain gas from entering burners until the air supply is available and, in the event of air failure, to shut off the gas supply.

39.12 If air for combustion is supplied mechanically by a source from which the flow may be interrupted, provision shall be made to shut off the fuel supply to the main burner and pilot assembly upon failure of the air supply. For a burner assembly having an input in excess of 2,500,000 Btu per hour (732 kW) the loss of combustion air shall result in safety shutdown so that a manual reset is required to restore the burner operation.

Exception: Fuel shutoff and safety shut-down, if applicable, upon failure of combustion air is not required for a burner that is equipped with a supervised secondary pilot as described in 40.1.8.

39.13 With respect to 39.10 and 39.12, loss of air during purge or any time at start-up prior to delivery of fuel, need not result in safety shutdown. However, no delivery of fuel shall be initiated before the air flow has been reestablished and the required prepurge has been completed. See 39.17.

39.14 A burner shall be equipped to provide preignition purging in accordance with 39.15 and 39.18, except such preignition purging is not required if the burner is equipped with a continuous pilot and the assembly is arranged so that any and all gas from the burner ports will be safely lighted and burned.

39.15 A forced or induced draft burner assembly shall provide preignition purging for the combustion chamber, heat exchanger, and flue passages of the incinerator to which the burner assembly is to be applied, immediately before ignition of an interrupted or intermittent pilot or before delivery of gas to the main burner for direct ignition by an electric igniter, whichever is applicable. Purging shall continue for a sufficient time to provide a minimum of four air changes of this volume. With the air flow proven and the air dampers proven to be open the air flow rate shall be at least equivalent of that provided for combustion at 60 percent of the rated high-fire input.

Exception: For a burner assembly having an input not exceeding 2,500,000 Btu per hour (732 kW), as an option, the purging may be accomplished at a damper opening that provides at least four air changes in not more than 90 seconds.

39.16 Purge periods at air flow rates not less than those indicated in (a) and (b) may be considered as providing purging in accordance with 39.15:

a) A purge period of 30 seconds, during which time air flow at a rate equivalent to that provided for combustion at rated, high-fire input of the burner assembly or incinerator is obtained.

b) A purge period of 60 seconds, during which time air flow at a rate equivalent to that provided for combustion at 60 percent of rated, high-fire input of the burner assembly or incinerator is obtained.

39.17 With respect to 39.15 – 39.16 if there is a loss of air during the purge, a complete required purge of four air changes or the required period of purge shall be provided after reestablishment of air flow.

39.18 A control device provided as an interlock in the burner fuel supply-combustion air system, or for a similar purpose shall comply with the requirements specified in the Standard for Limit Controls, UL 353.

40 Primary Safety Controls

40.1 General

40.1.1 Each burner assembly shall be provided with a primary safety control that will de-energize the main burner safety shutoff valve upon loss of flame at point of supervision.

40.1.2 Loss of flame at the point of supervision shall result in de-energization of the safety shutoff valve by the primary safety control and safety shutdown for the following burners:

a) Power gas burners and mechanical draft atmospheric gas burners having an input in excess of 2,500,000 Btu per hour (732 kW).

b) Any type of burner equipped with a manually lighted continuous pilot.

c) A burner employing direct electric ignition of main burner gas.

40.1.3 Following the loss of flame at the point of supervision and de-energization of the safety shutoff valve within the time interval specified in Table 40.1, the ignition means may be automatically reactivated for an attempt to restart the burner for a power gas burner or a mechanical draft burner having an input not exceeding 2,500,000 Btu per hour (732 kW) after completion of the purge in accordance with 39.15 or 39.16.

40.1.4 A primary safety control shall provide programming and monitor burner operation in accordance with Table 40.1 as appropriate.

40.1.5 The operation of the primary safety control shall be such that after the end of the main burner flame establishing period the combustion detector is responsive only to the properties of main burner flame.

40.1.6 The control system for a burner assembly equipped with a pilot for ignition of main burner flame shall be arranged so that no gas can flow to the main burner or burner group operating as a unit unless the pilot is proved. See 42.6.

40.1.7 Pilot supervision by the primary safety control shall be only at the point where the pilot flame will effectively ignite the gas at the main burner or burner group with the pilot burning with any flame capable of actuating the safety control.

40.1.8 If a pilot is not proved, the gas to the pilot shall be automatically shut off and safety shutdown established. In the event of pilot extinguishment the gas to such pilots shall be shut off within the time interval specified in Table 40.1. A pilot, independently supervised, having an hourly input of 5000 Btu/hr or less, intended to light a larger pilot which is supervised in accordance with 40.1.6, is acceptable.

40.1.9 When an automatically ignited pilot is used, the pilot flame shall be proved before the main fuel valve is energized. Fuel to the pilot shall be shut off and safety shutdown shall occur if the pilot flame is not proved.

40.1.10 If burner assemblies are designed for multiple installation in single devices, the automatic safety control mechanism of each burner assembly shall operate independently of the other, or equivalent safety features shall be provided so that in no case can any one burner operate unsafely.

Table 40.1
Required programming and timings based on maximum fuel input

Operation	Maximum firing rate per combustion chamber in million btu per hour		
	Above 400,000 Btuh (117,228 W) to 2,500,000 Btuh (732, 678 W)	**Above 2,500,000 Btuh (732,678 W) to 5,000,000 Btuh (1,465,356 W)**	**Above 5,000,000 Btuh (1,465,358 W) to 12,500,000 Btuh (3,663,389 W)**
Prepurge	Four air changes in 90 seconds with proven airflow, or at 60 percent damper opening, with both damper opening and airflow proven	Four air changes at 60 percent damper opening with both damper opening and airflow proven	Four air changes at 60 percent damper opening with both damper opening and airflow proven
Pilot type and flame establishing period	Intermittent or interrupted, 15 s, maximum[c]	Interrupted, 10 s maximum[c]	Interrupted, 10 s maximum[c]
Main burner flame establishing period when ignited by pilot	15 s maximum	10 s maximum	10 s maximum
main burner flam establishing period when ignited directly by electric igniter	15 s maximum	4 s maximum[b]	Not permitted
Flame failure reaction time	4 s maximum	4 s maximum	4 s maximum
Safety shutoff valve closing time after de-energization	5 seconds maximum	1 second maximum	1 second maximum
Action required on flame failure	One recycle permitted	One recycle permitted	Safety shutdown required
Proven low fire start	Not required	Required	Required
Combustion air proving	Required	Required	Required
Action required on loss of combustion air	Safety shutdown except may recycle once. See 39.10	Safety shutdown except may recycle once. See 39.10	Safety shutdown
Gas pressure supervision	Not required	Low and high gas pressure switches required	Low and high gas pressure switches required

[a] Maximum fuel input at light off not to exceed 2,500,000 Btu per hour (732,678W). See 41.3.

[b] The flame-failure reaction time is to be considered, the interval between the actual flame extinguishment and the time the safety shutoff device (such as a gas valve) is de-energized.

[c] The pilot flame establishing period shall not exceed 4 seconds if the pilot input exceeds 400,000 Btu per hour (117 kW). See 42.6.

40.1.11 Supervision of the main burner flame is not required on a burner equipped with an intermittent pilot that is supervised throughout the burner operating cycle in accordance with the Pilot Supervision Test No. 7 and Ignition, Gas-Electric High Tension Test No. 8, provided the maximum firing rate per combustion chamber does not exceed 2,500,000 Btu per hour for a mechanical draft burner.

40.1.12 Supervision of the main burner flame only shall begin at the end of the main burner flame-establishing period if:

a) The maximum firing rate per combustion chamber is more than 2,500,000 Btu per hour for a mechanical draft burner and 5,000,000 Btu per hour for an atmospheric burner;

b) The burner assembly is equipped with an interrupted pilot or an electric igniter for ignition of the main burner gas; or

c) The maximum firing rate per combustion chamber is more than 2,500,000 Btu per hour and modulating or high-low firing is employed.

If the main burner flame is not proved, safety shutdown shall be established.

40.1.13 A primary safety control shall be constructed and tested in accordance with the Standard for Automatic Electrical Controls for Household and Similar Use – Part 2: Particular Requirements for Burner Ignition Systems and Components, UL 372.

40.2 Fuel pressure controls

40.2.1 A burner shall be equipped with low and high gas pressure switches if:

a) The maximum firing rate per combustion chamber exceeds 2,500,000 Btu per hour; or

b) Regardless of the firing rate, the burner is equipped with an electric igniter for direct ignition of the main burner gas.

The switches shall cause a safety shutdown in the event the gas pressure varies by ±50 percent of the rated pressure downstream of the main burner regulator. The low gas pressure switch shall be located upstream of the safety shutoff valve or valves. The high gas pressure switch shall be located downstream of the safety shutoff valve or valves.

40.2.2 With respect to 40.2.1, the high gas pressure switch may be located downstream of the main burner regulator if it can be determined the burner is capable of operation at the intended pressure settings.

40.2.3 Gas pressure switches shall be constructed and tested in accordance with the Standard for Limit Controls, UL 353.

41 Ignition Systems – General

41.1 The electric igniter, pilot burner, and pilot and main burner flame-sensing devices shall be constructed and supported so that each will be fixed in its intended position.

41.2 The means for ignition shall be so designed and located as to reduce the risk of collection of carbon and other material, or the dislocation, distortion, or burning of parts when the burner assembly is tested in accordance with these requirements.

41.3 The construction of a burner assembly shall be such that the igniter assembly may be readily withdrawn from and replaced in the burner assembly during servicing of the igniter assembly and burner assembly without resulting in:

a) Reduction of the clearances between bare current carrying parts, electrodes, and grounded metal parts.

b) Changes in the air gap at electrode tips.

c) Reduction of the spacings between the high potential cables and grounded metal parts.

d) Changes in the position of the igniter or pilot relative to the area at which ignition is to be initiated.

41.4 Except as indicated in 41.5, the lighting of the main burner flame shall be accomplished by a pilot flame. An electric ignition system shall ignite only a pilot.

41.5 For an automatically ignited mechanical draft burner having a maximum firing rate not greater than 5,000,000 Btu per hour per combustion chamber, the lighting of the main burner flame may be accomplished directly by an electric igniter if the burner, in conjunction with the incinerator on which it is used, complies with Delayed Ignition – Test No. 9. However, the maximum fuel input that is ignited directly by an electric igniter shall not exceed 2,500,000 Btu per hour. See 41.6.

41.6 If the maximum firing rate of a burner on which the main burner flame is lighted directly by an electric igniter exceeds 2,500,000 Btu per hour per combustion chamber, the initial ignition input shall not exceed 2,500,000 Btu per hour. The ignition input shall be controlled by one or more of the following arrangements:

a) A low-fire start-up proved by an interlock arrangement.

b) A slow-opening gas valve arranged so that in 5 seconds after the valve is energized the fuel input rate to the burner does not exceed 2,500,000 Btu per hour.

c) Staged fuel input by either a step-opening valve or an arrangement of two separate valves (see). The second stage input shall be delayed not less than 5 seconds from the energization of the first stage.

41.7 The ignition system for the main burner shall be activated before the delivery of fuel to the ignition zone and shall remain active during the main burner flame-establishing period. If means for ignition is cut off at the termination of the main burner flame-establishing period, the ignition (pilot and any pilot or main flame electric igniter) shall remain off for the duration of that firing cycle and for the purge period required upon attempting the next firing cycle in accordance with 40.1.3.

42 Electric High-Tension Ignition

42.1 Spark igniters

42.1.1 Current carrying parts, such as a bus bar, electrode, or terminals, shall be enclosed or insulated to provide protection against accidental contact.

42.1.2 If an adjustable air deflector or similar part is employed in the vicinity of bare conductors, the construction shall be such that the part may be securely fixed to maintain any spacing required to conform to 42.2.2.

42.2 Electrodes and bus bars

42.2.1 Bare electrodes and bus bars shall be self-supporting when in place.

42.2.2 An electrode or bus bar supporting an electrode shall be designed so that it may be fixed in its proper position, and will maintain the desired gap.

42.2.3 An electrode or bus bar supporting an electrode shall be designed so that it may be fixed in its proper position, and will maintain the desired gap.

42.2.4 An electrode shall be prevented from rotating within its insulator, unless such rotation will not result in any change in spacing or alignment.

42.2.5 An electrode tip shall be of such design and material that extreme burning of its point will not result when the burner is tested in accordance with these requirements. A high-temperature alloy steel, or equivalent material, shall be used for the electrode tip.

42.3 Insulators

42.3.1 An insulator shall be made of ceramic insulating material or the equivalent, impervious to moisture and cleanable by wiping.

42.3.2 An insulator shall provide a distance, as measured across the surface of the insulator, between the nearest point of bare current carrying parts and the nearest electrically grounded metal surface as indicated in Table 42.1.

Table 42.1
Spacing over surface of insulators

Secondary voltage of ignition transformer	Minimum surface distance over insulator[a], inches (mm)	
Not more than 6,000	1	(25.4)
Not more than 10,000	1-1/2	(38.1)
Not more than 15,000	2	(50.8)

[a] For burners equipped with solid state ignition modules, the over-surface spacing shall be based on peak voltage of the ignition system. For solid state ignition systems, the over-surface spacing may be reduced upon successful completion of the dielectric test in Section 64.

42.3.3 An insulator included in a proved gas pilot assembly to be energized by a transformer having a secondary voltage of not more than 6,000 need not conform to 42.3.2 and Table 42.1 if ignition is to be for combustible air-gas mixtures only within or adjacent to a pilot tip or nozzle.

42.3.4 An insulator shall be so located that no detrimental accumulations of carbon will form on it when the burner is tested in accordance with these requirements.

42.4 Leads

42.4.1 Ignition cable shall have a voltage rating equal to or greater than the rated secondary voltage of the ignition transformer. The peak voltage rating of the ignition cable for burners equipped with solid state ignition modules shall be based on the peak voltage of the ignition system. If the ignition cable has only an RMS rating, the peak rating shall be determined by multiplying the RMS rating by 1.4. Each end of a lead shall be provided with a fixed loop, eyelet, or connector. A lead or cable shall be run individually in a manner to avoid sharp bends.

42.5 Transformers

42.5.1 A transformer shall be mounted as closely as possible to the spark gap to avoid long leads. Its location shall be such that it will not be placed within 1 inch (25.4 mm) of the floor when the burner assembly is installed in accordance with the manufacturer's installation instructions unless that portion of the case within 1 inch (25.4 mm) of the floor is waterproof.

42.5.2 A spacing of at least 1/8 inch (3.2 mm) shall be provided between a transformer secondary terminal insulator and any adjacent metal part other than the transformer case.

42.5.3 The preceding requirements for electric high-tension ignition systems are based upon the use of ignition energy that is essentially sinusoidal. Other types of systems employing ignition energy that is not essentially sinusoidal may be considered. Among the factors taken into consideration in determining the acceptability of such systems are dielectric properties, electrical spacings, the true root-mean-square (rms) value and the peak voltage of the system, the average pulses, duration of the pulses, and duty cycles.

42.6 Gas pilots

42.6.1 Except as indicated in 41.4, each main burner unit shall be equipped with a proved pilot to accomplish proper ignition of the main burner. If multiple burners are operated as a unit, a sufficient number of pilots shall be employed to accomplish the ignition of all main burners smoothly. The input to a pilot or the total input to all pilots being ignited simultaneously shall be in accordance with 42.6.2 and shall not exceed 5 percent of the maximum input of the main burner or total maximum input of all burners being operated as a unit for any burner employing intermittent pilots.

42.6.2 If the input to a pilot or total input to all pilots being ignited simultaneously exceeds 400,000 Btu per hour the burner in conjunction with the incinerator on which it is used shall comply with the Delayed Ignition Test No. 9.

42.6.3 A pilot burner not automatically lighted shall be placed so that it can be safely lighted manually.

42.6.4 The gas supply pressure to the pilot or a group of pilots shall be regulated separately of the main burner gas regulator. The pilot-supply line shall be connected, or arranged to permit connection, upstream from all main burner valves and the main burner regulator.

42.6.5 Primary air openings and orifices shall be accessible for servicing.

42.6.6 Tips of continuous burning aerated pilot burners shall be made from AISI 416 steel or material having at least equivalent heat and corrosion resistant characteristics. Nickel alloys of greater than 1.0 percent nickel, because of catalytic cracking effect, are not acceptable.

42.6.7 A pilot burner, electric igniter, and pilot flame-sensing device shall be supported in such a manner that their position relative to each other and to the ports of the main burner or burners will remain fixed and means shall be provided to reduce the risk of unintentional incorrect assembly or mounting of any pilot burner in relation to the burner being served.

42.6.8 Clearance shall be provided for removal and replacement of the pilot burner without kinking the pilot gas tubing.

42.6.9 If a pilot burner supply line is taken from a horizontal line, the connection shall be made either at the side or top of the pipe. The pilot supply line shall be connected upstream of all main burner valves and regulators.

43 Fittings and Piping

43.1 An opening threaded for pipe connection shall be threaded in accordance with the Standard for Pipe Threads, General Purpose (Inch), ANSI/ASME B1.20.1.

43.2 An opening for field attachment to pipe larger than nominal 3 inch ANSI/ASME B1.20.1 pipe size shall be provided with a flanged pipe connection conforming to Class 25, 125, 250, and 800 requirements of the Standard for Cast Iron Pipe Flanges and Flanged Fittings, ANSI/ASME B16.1.

43.3 A fitting having openings threaded for pipe connections shall be capable of withstanding, without damage or leakage, the turning effort (torque) specified in Table 43.1 exerted as if to screw the fitting onto a pipe or into a pipe fitting. A standard pipe fitting need not be subjected to this test.

Table 43.1
Torque requirements for pipe connections

Pipe size, inches	Torque, pound-inches
1/4	250
3/8	450
1/2	800
3/4	1000
1	1200
1-1/4	1450
1-1/2	1550
2	1650
2-1/2	1750
3	1800
3-1/2	1850
4	1900

43.4 A tool which fits snugly about the fitting, or to a section of the shank shaped for a wrench, if such section is provided, is to be utilized to apply the turning force. The turning force is to be applied to the hex of the fitting adjacent to where it is attached to piping or, if no hex is provided in this position, to the body of the fitting. The measured torque specified above is to be applied to the fitting to screw it onto an extra-heavy pipe, Schedule 80, or into a pipe fitting of appropriate size. After the force has been applied, the fitting is not to leak when subjected to a hydrostatic pressure equivalent to one and one-half times the maximum working pressure.

43.5 Tapped holes for gas valves, pilots, or other branch supply lines shall have not less than 3-1/2 pipe threads.

43.6 Iron or steel, gas-supply pipe employed on the incinerator shall comply with the Standard for Wrought Steel and Wrought Iron Pipe, ANSI B36.10M. If brass or copper pipe is employed, it shall be dimensionally equivalent to iron pipe. Substantial malleable iron, steel, brass, or copper pipe fittings shall be used with pipe. Unions, where used, shall be the ground-joint type or the equivalent.

43.7 Ends of piping and tubing shall be reamed to remove obstructions or burrs.

43.8 Compounds used on threaded joints of gas piping shall be resistant to the action of liquefied petroleum gases.

43.9 Bent supply piping shall have the bends smoothly made without any appreciable reduction in the cross-sectional area, shall reveal no imperfections occasioned by the bending process, shall be annealed if necessary to remove internal stresses; and shall be cleaned inside to remove loose particles.

43.10 Tubing shall be arranged to avoid being physically damaged, such as by closely following the contour of the burner assembly. Tubing connections shall be made by means of compression or flare type fittings with steel or brass nuts. A fitting requiring the use of a gasket to obtain a gas-tight joint shall not be used.

43.11 If a vertical section of piping is supplied on the upstream side of the gas controls, a trap in this piping shall be supplied by the manufacturer. If a vertical section of piping is not supplied, the installation instructions shall require the installation of a trap at the inlet of the gas connection of the unit.

43.12 Seamless drawn aluminum or copper tubing employed in the fabrication of factory assembled incinerators shall be not less than 1/4 inch (6.4 mm) outside diameter and shall have a wall thickness not less than that shown in Table 43.2.

Table 43.2
Wall thickness – aluminum and copper tubing

Outside diameter, inches	Wall thickness, inches
1/4	0.029
5/16	0.029
3/8	0.032
7/16	0.032
1/2	0.035
9/16	0.038
5/8	0.038
3/4	0.045
7/8	0.045
1	0.049
1-1/8	0.049
1-1/4	0.055
1-3/8	0.055

43.13 Aluminum tubing shall not be exposed to condensate or to temperatures in excess of 700°F (371.1°C) and shall not be acceptable for use where it passes through insulating material of other than neutral reaction unless the tubing is adequately protected from the insulation.

43.14 Steel tubing of the seamless, brazed, or welded type shall be not less than 1/4 inch (6.4 mm) outside diameter and shall have a wall thickness not less than shown in Table 43.3.

Table 43.3
Wall thickness – steel tubing

Outside diameter, inches	Wall thickness, inches
1/4	0.028
5/16	0.028
3/8	0.028
1/2	0.028
5/8	0.035
3/4	0.035
7/8	0.049
1	0.049
1-1/8	0.049
1-1/2	0.065

43.15 Steel tubing having a wall thickness of 0.053 inch (1.34 mm) or less shall be constructed of corrosion resistant material such as stainless steel or shall be plated, dipped, coated, or otherwise treated to resist external corrosion.

43.16 Cadmium plating shall have a thickness of not less than 0.0003 inch (0.0076 mm) except on a part where threads constitute the major portion of the area, in which case the thickness of the cadmium plating shall be not less than 0.00015 inch (0.0038 mm). Zinc plating shall have a thickness of not less than 0.0005 inch (0.0038 mm) except on a part where threads constitute the major portion of the area, in which case the thickness of the zinc plating shall be not less than 0.00015 inch (0.0038 mm).

43.17 Copper tubing or tubing with internal copper surfaces, used for conveying gas, shall be internally tinned or equivalently treated to resist sulphur corrosion. Such tubing shall not be exposed to temperatures in excess of 350°F (176.7°C).

43.18 Flexible metallic hose is not considered a substitute for rigid piping or tubing as ordinarily employed. Its use should be confined to applications where rigid piping or tubing is impractical and where flexible connections cannot be avoided. It is not intended to be subjected to torsional, tensile, or excessive vibration or bending stresses or to abrasion. It is not considered suitable for use in conjunction with safety devices or where bending is caused by automatic operation.

43.19 A fuel line shall terminate in a manner which will permit connection to the burner assembly. A fuel line opening shall be plugged or capped to reduce the risk of foreign material entering prior to installation.

43.20 A 1/8 inch (3.2 mm) iron pipe size or larger plugged tapping, accessible for test gauge connection, shall be furnished downstream from the last main line gas control for measuring gas pressure at the burner.

44 Valves and Regulators

44.1 Automatic safety shutoff valves

44.1.1 Each main burner supply line shall be equipped with a safety shutoff valve or valves which will close, independent of external force and with sufficient closing force to provide tight shutoff under normal operating conditions. The following arrangements comply with this requirement:

a) Either two valves in series, one of which is a safety shutoff valve, or one safety shutoff valve of the type incorporating a proof of closure switch, when the maximum firing rate per combustion chamber does not exceed 2,500,000 Btu per hour (732 kW). The two valve arrangement may be incorporated into a single control body.

b) Two safety shutoff valves in series, or one safety shutoff valve of the type incorporating a proof of closure switch, when the maximum firing rate per combustion chamber exceeds 2,500,000 Btu per hour but is not more than 5,000,000 Btu per hour (1.46 MW); or

c) Two safety shutoff valves in series, one of which is of the type incorporating a proof of closure switch when the maximum firing rate per combustion chamber exceeds 5,000,000 Btu per hour. Burners having a maximum firing rate per combustion chamber in excess of 12,500,000 Btu per hour (3.66 MW) and equipped to fire fuel gas having a specific gravity less than one shall also include a normally open 3/4 inch (19.1 mm) or larger electrically operated valve in a vent line located between the two safety shutoff valves.

Exception: If an automatic valve proving system is installed to verify that both safety shutoff valves are leak-free during each burner cycle and functions to prevent light-off in the event of a leak, a normally open vent valve is not required to be used.

44.1.2 Each pilot supply line shall be equipped with a safety shutoff valve. This may be incorporated into a main line combustion gas valve.

44.1.3 Safety shutoff valves shall shut off after being de-energized within the time limits specified in Table 40.1.

44.1.4 Safety shutoff valves shall be constructed so that they may not be restrained or blocked in the open position. Such valves shall close upon being de-energized regardless of the positions of damper operating levers or reset handles.

44.1.5 An electrically operated safety shutoff valve shall not depend on electricity to shut off the gas supply.

44.1.6 A pressure operated safety shutoff valve shall close upon failure of pressure.

44.1.7 A bypass to provide for minimum flame may be installed around a valve used to regulate fuel input only. A bypass shall not be installed around a safety shutoff valve or a combination input control and safety shutoff valve.

44.1.8 Means shall be provided to facilitate testing automatic valves for leakage when in the closed position.

44.1.9 Automatic safety shutoff valves shall be constructed and tested in accordance with the Standard for Electrically Operated Valves, UL 429 or equivalent nationally recognized automatic valve safety standard.

44.2 Manually operated valves

44.2.1 Manually operated main shutoff and pilot shutoff valves shall have an attached handle which is positioned parallel to the gas flow when the valve is in the open position. These valves shall be located so that they are accessible. These valves shall be stamped and/or marked for their specifically designed use, (such as "g" for gas, or "wog" for water, oil, or gas), and they shall have indicated ON and OFF positions. These indications may be by means of a lug on the valve stem which is parallel to the flow of gas when the valve is open and perpendicular to the flow of gas when the valve is closed. The valve shall also incorporate stops for both fully open and fully closed positions.

44.2.2 A manually operated main burner shutoff valve shall be installed in the line supplying all main burners and shall be located upstream of main burner gas control and automatic safety shutoff valves. Another manually operated gas valve shall be installed in the gas line of the main burner, located downstream of all automatic safety shutoff valves to permit the testing of the safety shutoff valves for leakage.

44.2.3 A manually operated pilot shutoff valve shall be located in the gas supply line to the pilot burner(s).

44.2.4 On manually lighted burners, a manually operated main burner test valve (checking gas cock) shall be provided downstream from the safety shutoff valve for each main burner. The test valve(s) shall be interlocked with the safety control circuit and arranged so that the main burner safety shutoff valve(s) must be opened against their associated closed test valve(s).

44.2.5 Manually operated valves shall be constructed and tested in accordance with the Standard for Valves for Flammable Fluids, UL 842, or equivalent nationally recognized manual valve safety standard.

44.3 Gas pressure regulators

44.3.1 Spring or weight loaded regulators shall have springs or weights covered by a housing. A weight and lever type of regulator shall not be used.

44.3.2 The diaphragm housing of a gas pressure regulator shall be made so that a vent pipe may be connected. See Marking section for tagging of vent line connection.

Exception: When the gas pressure regulator is provided with an integral leak limiting orifice, the vent pipe connection and marking of the connection need not be provided.

44.3.3 The gas pressure regulator shall be located upstream of all automatic gas controls except as indicated in 44.3.4.

44.3.4 The gas pressure regulator may be located downstream of the automatic safety shutoff valve(s) provided the burner is marked as indicated in 77.3.

44.3.5 Except as indicated in 44.3.6, a gas pressure regulator(s) shall be furnished.

44.3.6 An incinerator may be furnished without a pressure regulator provided it is permanently marked to declare that a regulator capable of being adjusted to the incinerator's designed burner manifold pressure shall be installed at the time of installation of the incinerator. See 77.2.

44.3.7 Gas pressure regulators shall be constructed and tested in accordance with ANSI Z21.18, Pressure Regulators, or equivalent nationally recognized pressure regulator safety standard.

45 Bleeds and Vents

45.1 A bleed line from a diaphragm valve and an atmospheric vent line from a gas-pressure regulator, pressure interlock switch or any other gas train component that requires atmospheric air pressure to balance a diaphragm, shall be provided with threaded pipe connection for venting in accordance with the manufacturer's instructions. Unless the burners are equipped for constant-burning pilot only, the vent line of a regulator shall not vent into the combustion chamber. Bleed lines shall be not less than 1/4 inch (6.4 mm) outside diameter tubing.

45.2 Bleed lines from diaphragm control valves and vent lines from gas-pressure regulators that vent into the combustion chamber shall terminate in burner tips made of a metal having a melting point in excess of 1450°F (788°C). They shall be located so that the escaping gas will be readily ignited from the pilot flame and the heat liberated will not impair the operation of the thermal element. Bleed line burners shall be securely held so that the ports are in a fixed position relative to the pilot flame.

45.3 A vent line from a gas-pressure regulator shall not be connected into a common line with a bleed line from a gas-operated diaphragm or from a relief valve.

45.4 Atmospheric vent lines, when manifolded, shall be connected to a common vent line having a cross sectional area not less than the area of the largest vent line plus 50 percent of the areas of all the additional vent lines.

45.5 Gas vent lines with normally open, fully ported, electrically operated valves shall be sized in accordance with Table 45.1.

Table 45.1
Vent line sizing

Fuel line size, nominal pipe size, inches	Vent line size, nominal pipe size, inches
Up to 1/1-2	3/4
2	1
2-1/2	1-1/4
3	1-1/4
4	2
5	2
6	2-1/2
8	3

PERFORMANCE

46 General

46.1 The performance of the gas-burning incinerator shall meet the applicable requirements when tested as described herein. An incinerator of a type not described specifically herein shall be tested in accordance with the intent of these requirements. If any indications are observed during the tests prescribed that a incinerator will not continue to meet the requirements in normal usage, supplementary tests shall be conducted at the discretion of the third party safety certifier to provide conformance to this Standard.

46.2 Incinerators are tested normally to determine suitability for installation on noncombustible floors and with clearances to combustible walls and ceilings as specified by the manufacturer. Incinerators may be recommended for installation on combustible floors if tests in accordance with these requirements demonstrate that, when so installed, temperatures will not exceed designated limits.

46.3 An evaluation of any condensation that may collect in the flue gas ductwork or components shall be undertaken to determine the pH content. The pH content is to be measured as undiluted condensate. An initial condensate sample is to be taken upon a cold start and additional samples are to be taken to be representative of all firing conditions that produce condensate. The pH measurement is to be performed in accordance with the Standard Test Method for pH of Aqueous Solutions With the Glass Electrode, ASTM E70. If the pH is greater than or equal to 3.0, no further evaluation of the effects of the condensate is required. If the pH concentration is less than 3.0, the venting system of the appliance shall be evaluated in accordance with the Standard for Venting Systems for Gas Burning Appliances, Categories II, III, and IV, UL 1738.

47 Test Installations

47.1 The incinerator in the as received condition is to be placed in a partial enclosure formed by two walls of 1 inch nominal thickness wood boards or plywood 3/4 inch (19.1 mm) thick, set at right angles and finished in flat black. All joints are to be sealed or tight. The walls of the partial enclosure are to extend 3 feet (0.9 m) beyond the end and side of the incinerator and at least 1 foot (0.3 m) above the top of the incinerator. The wall is to be the minimum distance specified by the manufacturer from the side and back of the incinerator.

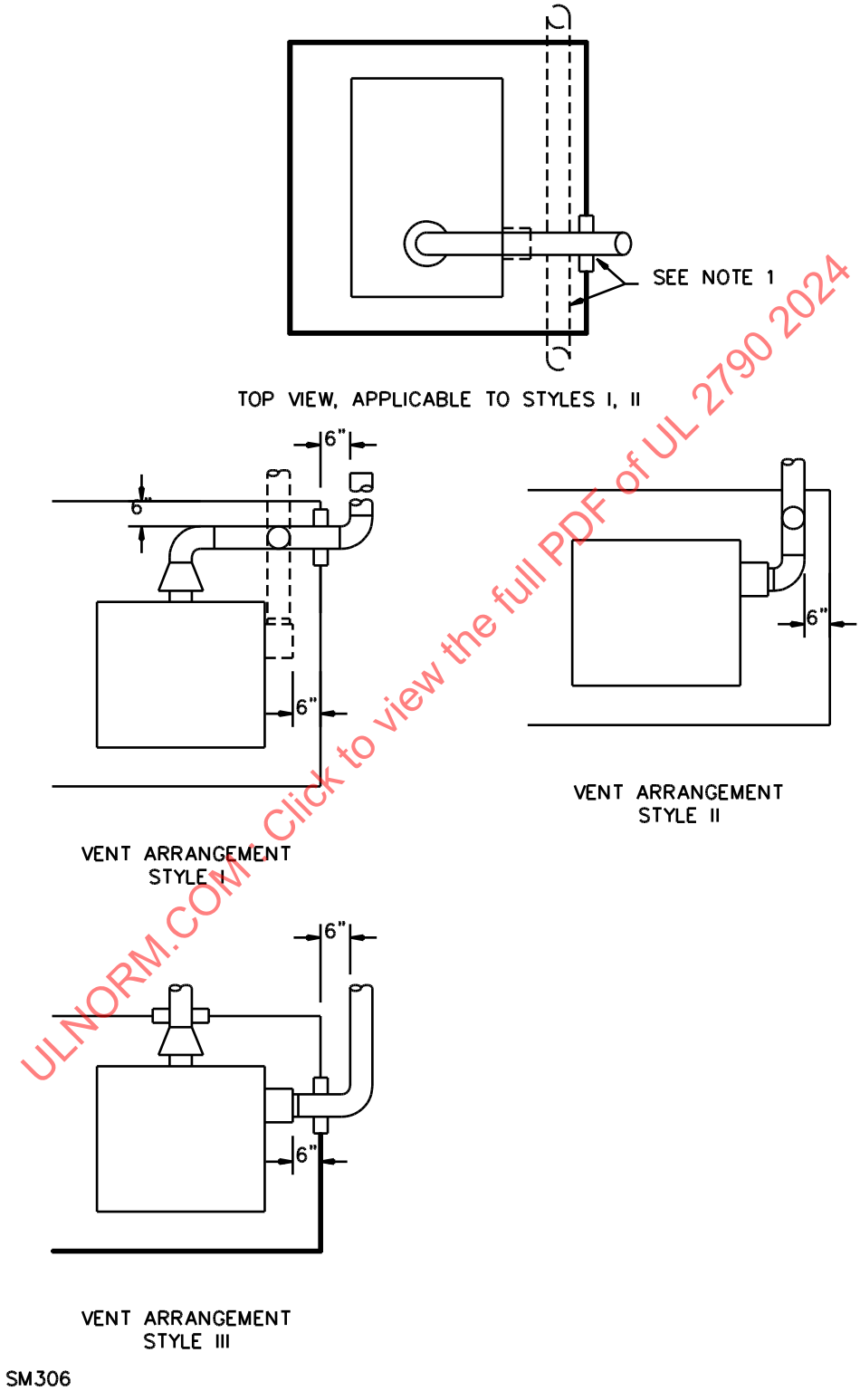
47.2 A ceiling of equivalent construction is to be placed above the partial enclosure. Clearances from chimney and vent connectors are to be not less than 6 inches (152 mm).

47.3 As an alternative to the above, the partial test enclosure may be eliminated and thermocouples attached to the outer casing panels as specified by 48.3.4 – 48.3.6. The temperature at points on external surfaces of the incinerator, except within 9 inches (229 mm) of the flue collar or any inspection or relief opening, shall not exceed the values specified in Table 60.1.

47.4 If the flue gases are vented horizontally, a length of single wall vent pipe is to be run horizontally through the wall of the test structure. An elbow and vertical vent pipe is to be attached on the far side of the wall to provide a vent arrangement similar to Style III, Figure 47.1. If the flue gases are vented vertically, a vertical vent pipe is to be attached to the vent collar of the incinerator.

Figure 47.1

Vent arrangement



47.5 If the incinerator is designed for direct installation on combustible flooring, the floor beneath the incinerator is to be 1 inch (25.4 mm) white-pine flooring superimposed by one layer of building paper; and then by 3/4 inch (19.1 mm) plywood, unpainted or finished with clear sealer.

47.6 The enclosure is to be constructed of 1 inch (25.4 mm) nominal thickness wood boards or plywood 3/4 inch (19.1 mm) thick finished in flat black with all joints sealed.

47.7 Incinerators with vertical flue outlets are to be tested with two vent arrangements, Styles I and III, as shown in Figure 47.1. Incinerators having horizontal flue outlets are to be tested with two vent arrangements, Styles II and III, as shown in Figure 47.1. A closed insulating thimble, 4 inches (102 mm) larger in diameter than the vent pipe, is to be used where the vent pipe may pierce the enclosure. For test purpose, a single-wall vent pipe is to be used with the specified clearance to test wall and ceiling surfaces.

48 Instrumentation

48.1 Draft measurement

48.1.1 Draft is to be measured by a draft gauge which may be read directly to 0.005 inch (0.13 mm) water column and which has an accuracy of ±0.0025 inch (0.064 mm). A gauge is to be checked for zero reading at the beginning and the end of each test.

48.2 Power measurement

48.2.1 The total electrical input to an incinerator is to be measured in amperes or watts.

48.2.2 An ammeter, wattmeter, or voltmeter is to have a maximum scale range of not more than 1-1/2 times the value to be measured. The smallest scale division is to be not more than 1/50 of the maximum scale range.

48.3 Temperature measurements

48.3.1 Unless otherwise indicated, surface temperatures are to be determined by a potentiometer and bead type thermocouples not larger than 24 AWG.

48.3.2 Thermocouples are to be placed on surfaces of the test enclosure at various locations as may be required to observe maximum temperatures during tests. Where the vent connector pierces the enclosure, temperature measurements on the inside surfaces of the enclosure are to be made 6 inches away from the vent connector. Thermocouples are to be attached to other pertinent materials and parts, such as those in Table 61.1.

48.3.3 If electrical conductors are involved, temperatures are to be measured on surfaces of the conductor insulation, which conductors are to be placed against enclosure surfaces they are likely to touch. The junction of the thermocouple should be held in good thermal contact with the surface of electrical conductors, preferably with an adhesive or cement. Pressure sensitive tape may be used, provided good thermal contact is achieved, and provided the application of the tape does not create air spaces adjacent to the conductor or between layers of tape and provided that the tape has an emissivity comparable to that of the conductor.

48.3.4 Thermocouples are to be secured to wood surfaces by staples over insulated portion of the wire and with the tip held in a good thermal contact with the surface by pressure sensitive tape; except that for zero clearance, the thermocouples are to be applied to surfaces of the incinerator at points of zero clearance.

48.3.5 Thermocouples are to be attached to metal surfaces at high temperature by welding, soldering or brazing. The attachment should be made with a minimum projection of the thermocouple lead and the brazing metal outward from the metal surface. Thermocouples may be attached to metal surfaces at lower temperature with cement or pressure sensitive tape, provided good thermal contact is achieved and provided that the tape does not create an air space adjacent to the metal surfaces.

48.3.6 Thermocouples are to be attached to surfaces other than as described above by being cemented or taped to the surface in a manner to assure good thermal contact with the surface. The temperature on the surface of the casing of portable and mobile heaters is to be determined by a thermocouple attached to the surface under a flexible, oven dry, felted asbestos pad, 6 square inches (38.7 square mm), 0.4 inch (10.2 mm) thick, and weighing not less than 1.0 nor more than 1.5 pounds per square foot (4.9 nor more than 7.3 kgs per square meter).

48.3.7 Temperatures are to be ascertained by temperature changes of not more than 5°F (3°C) for three consecutive readings taken 15 minutes apart at observed maximum temperature points.

48.3.8 Incinerators are to have attached a 3 foot (.91 m) length of uninsulated black-iron pipe, the same size as the vent collar or induced-draft fan outlet of the incinerator. The pipe may be attached directly to a vertical or horizontal flue-gas outlet.

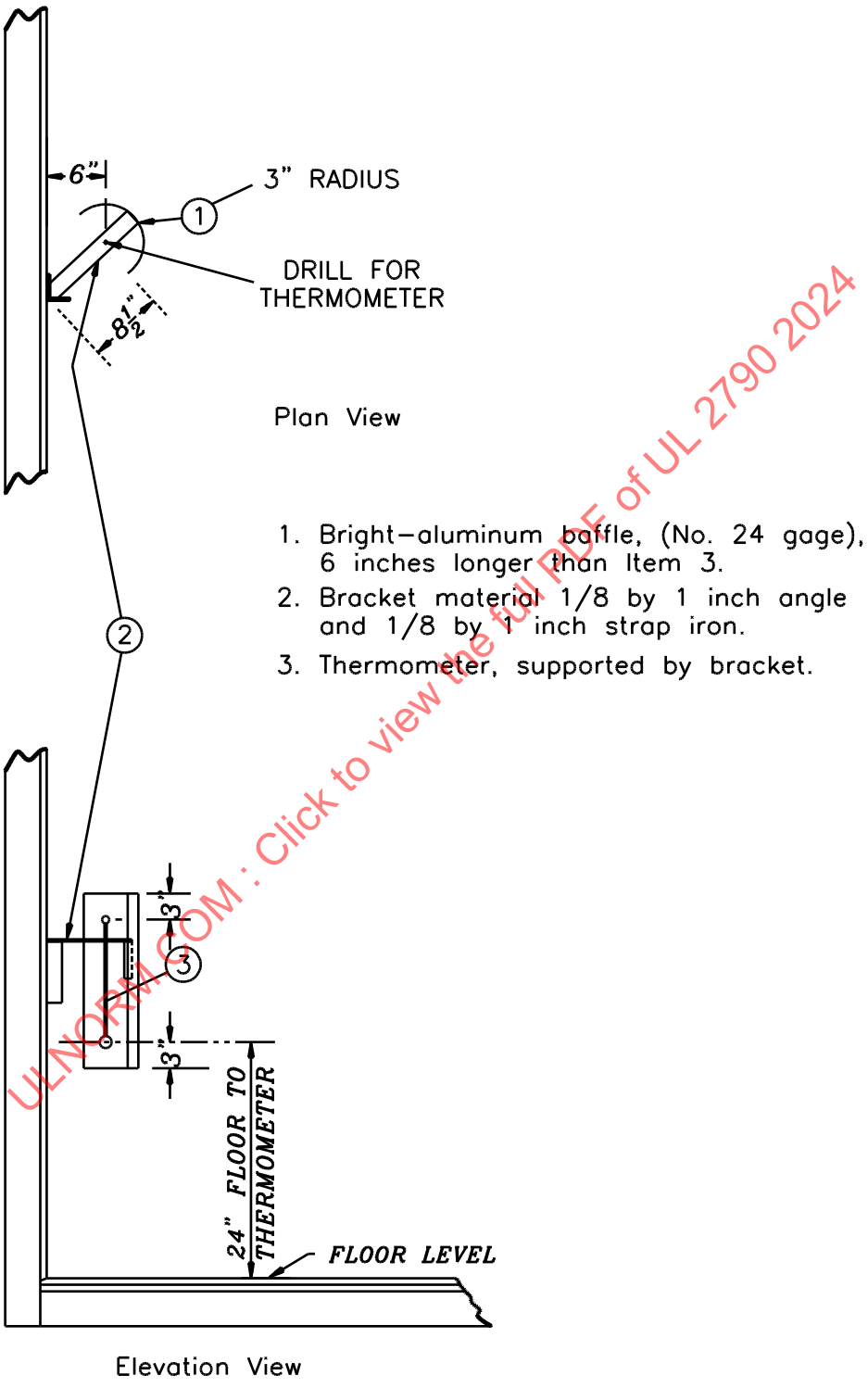
48.3.9 Two lines, intersecting at right angles, are to be established in the plane of measurement at right angles to the axis of the vent pipe within 1 foot (.3 m) of the normal flue-gas outlet of the incinerator. They are to be oriented so that they will divide the cross-sectional area in the vent pipe into quadrants. One temperature measurement is to be taken at the intersection of the two lines. Eight temperature measurements are to be taken, in two sets of four along each line, at points one-third and two-thirds of the distance from the intersection to the periphery. The temperature is to be determined with a bead type thermocouple not larger than 24 AWG successively placed at the specific positions. The flue-gas temperature is to be the average of these nine individual readings.

48.3.10 Room temperature is to be taken as the average of two shielded thermometers, see Figure 48.1, located as indicated by Figure 48.2. As an alternate, 24 AWG thermocouples may be used, located as indicated in Figure 48.2.

48.3.11 Devices not equipped with draft hoods are to have attached a 3 foot (.91 m) length of uninsulated black-iron pipe, the same size as the vent collar or induced-draft fan outlet of the device. The pipe may be attached directly to a vertical or horizontal flue-gas outlet.

Figure 48.1

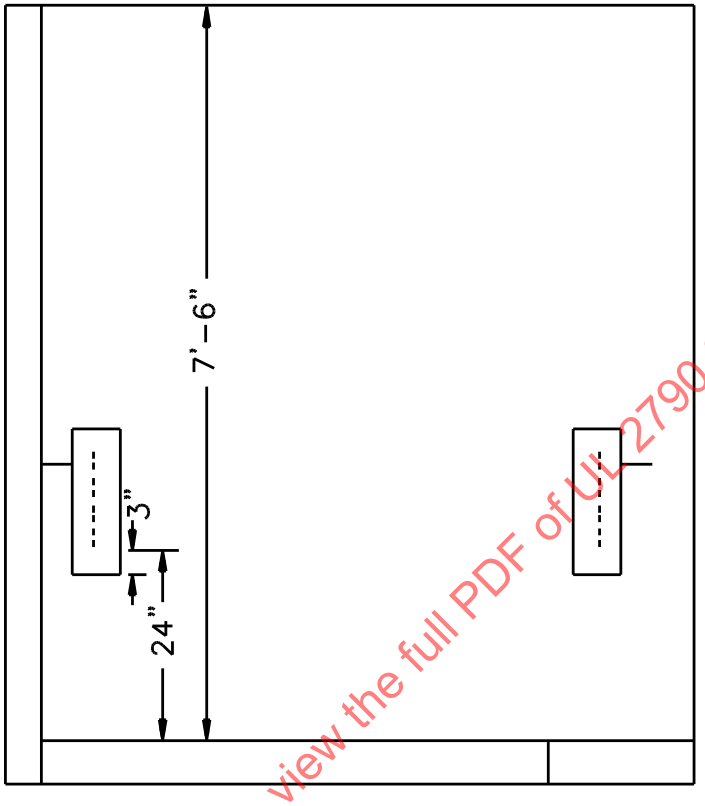
Thermometer shield



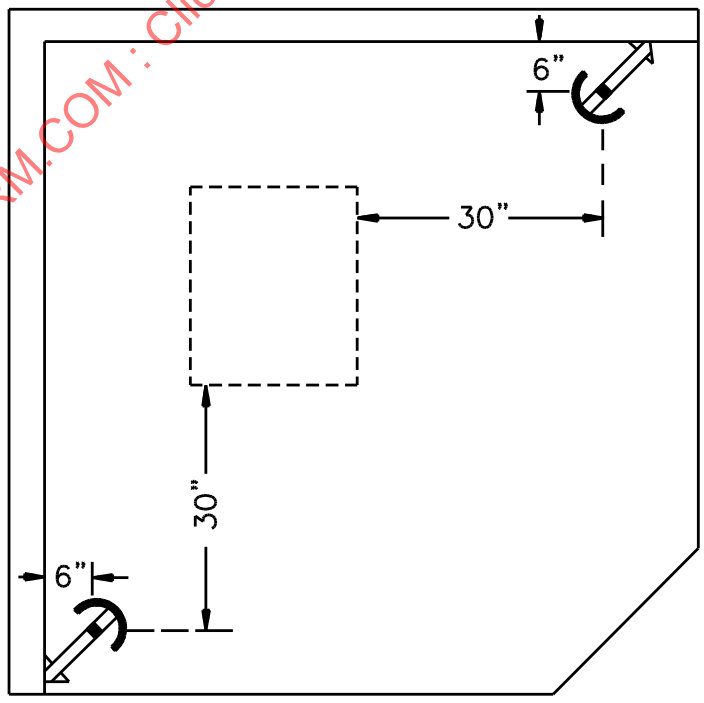
IA59–3

Figure 48.2

Test enclosure for temperature test



Elevation View



Location Plan

SM302

49 Test Methods

49.1 Firing conditions

49.1.1 The conditions for firing burners during tests outlined in these requirements are to be as described below unless otherwise directed by an individual test requirement.

49.1.2 The draft is to be as recommended by the manufacturer.

49.1.3 The firing rate at high fire is to be equivalent to the rated input of the incinerator being fired.

49.1.4 The firing rate at intermediate fires is to be as recommended by the manufacturer.

49.2 Test voltages

49.2.1 Unless otherwise specified, burners are to be tested at the potentials indicated in Table 49.1 for each test as detailed in the describing the test.

Table 49.1
Test voltages

Rated voltage	Normal test voltage	Overvoltage	Undervoltage[a]
110 – 120	120	132	102
208	208	229	177
220 – 240	240	264	204
254 – 277	277	305	235
440 – 480	480	528	408
550 – 600	600	660	510
Other	Rated	110 percent rated	85 percent rated

[a] Values in this column are applicable to alternating-current potentials. Undervoltage tests for a direct-current burner or component are to be conducted at 80 percent rated voltage.

50 Power Input Test – Test No. 1

50.1 The power input to an appliance shall be no more than 110 percent of the marked rating of the appliance.

50.2 To determine if an appliance complies with the requirement specified in Section 59, Temperature control – Test No. 10, the power input is to be measured with the incinerator at the temperature attained under intended operating conditions, full-load conditions, and while connected to a supply circuit of rated voltage as specified in 49.2.1.

51 Combustion – Test No. 2

51.1 Combustion shall be complete in the space provided by the incinerator or, if a burner assembly in the space recommended by the manufacturer, and no carbon monoxide in concentration in excess of 4/100 of 1 percent shall be present in air free samples of the flue gases taken over the full operating range of the burner assembly.

51.2 Complete and stable combustion shall be maintained at the minimum rate of firing or during any sudden change in the gas firing rate between maximum and minimum rates. Ignition shall be accomplished safely.

51.3 The maximum temperature of flue gases during any of the tests in Sections 59 and 60, Temperature Control Test and Temperature Test, at the maximum input recommended by the manufacturer shall not be in excess of the designed temperature or the limits of Table 60.1.

51.4 With respect to 51.3, determination that the flue gases in the vent pipe are at a negative pressure are to be made in the center within the vent pipe, 6 inches (152 mm) down-stream from the connection of the vent pipe to the flue gas outlet of the incinerator. The vent pipe is to be connected in accordance with 48.3.11. The pressure of the flue gases shall be negative at all permitted inputs of the incinerator.

51.5 The performance of a burner assembly or incinerator during this test shall be such that:

a) Ignition is obtained on each cycle within the expected safe period of time.

b) Ignition is obtained at each cycle without flash of flame outside the heating devices being fired and without damage to parts of the incinerator.

c) Stable fires are obtained at all operating firing rates.

d) The concentration of carbon monoxide in the flue gases is not in excess of 4/100 of 1 percent in an air free sample taken at all firing rates.

e) No soot has been deposited on surfaces of the heat exchanger, flue passages, or vent connector of the heating devices fired for the test.

f) Surfaces of the fire box, hearth, electrodes, and igniters and their insulators are free from detrimental formation of carbon, soot, and tar.

g) A pilot does not deposit detrimental carbon when adjusted according to the manufacturer's instructions.

51.6 All heating surfaces in contact with combustion products and the vent pipe of the incinerator to be fired for the test are to be thoroughly cleaned before the combustion test is begun.

51.7 The incinerator is to be arranged for operation in accordance with the instructions furnished by the manufacturer. The incinerator is to be fired at a rate within the rating of the incinerator.

51.8 Tests are to be conducted at normal gas pressures. The manifold pressure is to be as recommended by the manufacturer.

51.9 The incinerator is to be fired with the test gases for which the incinerator is rated. The input, air-fuel ratio, and other operating conditions are to be in accordance with the manufacturer's instructions. The temperature control is to be bypassed to permit continued operation when required by a test. During test, the temperature within the incinerator is to be not greater than its rated temperature.

52 Burner Endurance – Test No. 3

52.1 Ignition obtained during each cycle, flames not flash outside the heating appliance, no tar or flocculent soot buildup was observed on heat exchanger or burner surfaces, the pilot did not deposit detrimental carbon and the electrical rating consistent for each component employed.

52.2 A burner assembly of the ON and OFF type is to be fired 10 minutes ON and 10 minutes OFF for intermittent firing tests.

52.3 A modulating burner assembly is to be fired in successive cycles, each cycle consisting of 10 minutes on high fire, 10 minutes on intermediate fire, 10 minutes on minimum fire, and 10 minutes off for intermittent firing tests.

52.4 During test periods, observations and recordings are to be made of the draft on each operating rate, ignition, and combustion characteristics, combustion-chamber conditions, and any unnatural performance.

52.5 The fuel burning rate, draft over fire, CO_2 and CO are to be observed and recorded for each operating fire.

52.6 The duration of these tests is to be that required to obtain conclusive performance data.

52.7 Measurements of flue-gas temperature is to be made. The maximum flue-gas temperature is not to exceed the limits specified by the manufacturer.

53 Combustion Air Failure – Test No. 4

53.1 A mechanical-draft burner assembly or incinerator shall not operate improperly during interruption and upon restoration of the combustion air supply, as determined by test in accordance with 53.2 and 53.3.

53.2 The initial conditions for the test to determine conformance to the preceding paragraph are to be as for the Combustion Test. The test may be conducted during the course of the Combustion test. While the burner assembly or incinerator is being fired at any operating rate, the fan supplying air for combustion is to be stopped, i.e., by disconnecting the fan motor only from the electrical circuit, by disconnecting any flexible coupling, or by removing any belt needed to drive the fan. Fuel to the main burner is to be shut off in accordance with 53.3.

53.3 The fuel shall be shut off due to the inherent design of the burner assembly or by action of a control before any conditions develop that may cause a risk of fire or explosion. For an automatically lighted burner assembly whose maximum rated input does not exceed 2,500,000 Btu per hour (732 kW) the light off may be accomplished automatically upon restoration of the air supply after completion of the purge in accordance with Section 41. For a manually lighted burner and for an automatically lighted burner whose maximum rated input is in excess of 2,500,000 Btu per hour a manual reset shall be necessary to restart the burner after restoration of the air supply.

54 Undervoltage – Test No. 5

54.1 A burner assembly or incinerator shall operate in accordance with these requirements when tested at a voltage of 85 percent of rated voltage for alternating current or 80 percent of rated voltage for direct current incinerators.

54.2 The initial conditions for test are to be as for the Combustion Test. The test may be conducted during the course of the Combustion Test. The voltage of the power supply to the burner assembly or incinerator is to be regulated to maintain the minimum voltage specified and the burner assembly ignited and fired at high fire in the intended manner until steady-state conditions are attained.

54.3 The performance of the burner or incinerator shall be such that:

a) Ignition of the main burner flame is effected as intended during the five ignition trials.

b) Flames do not flash outside the incinerator being fired nor damage incinerator parts.

c) Combustion is complete and stable.

d) The concentration of carbon monoxide in an air free sample of the flue gas taken at the high-fire rate does not exceed 4/100 of 1 percent.

e) The burner assembly is capable of operation without interruption.

55 Power Interruption – Test No. 6

55.1 A power operated burner assembly or incinerator shall not operate improperly upon interruption of the power supply. Upon restoration of the power supply, the burner assembly or incinerator shall require manual restart or shall safely resume normal operation automatically.

55.2 The initial conditions for test to determine conformance to the preceding paragraph are to be as for the Combustion Test. The test may be conducted during the course of the Combustion Test. While the burner assembly or incinerator is being fired at any operating rate, the power supply is to be interrupted. The power is then restored after being interrupted for any period of time. The gas safety valve(s) shall be de-energized and fuel to the main burner shall be shut off within the time limit specified in Table 40.1.

55.3 The fuel is to be automatically shut off by action of a safety control. The burner assembly is to require manual restart to fire the burner assembly upon restoration of the power supply, or an automatically lighted burner assembly may restart automatically upon restoration of the power supply provided safe automatic reignition is obtained.

55.4 A burner assembly or incinerator equipped with multiple igniters, each of which is capable of functioning independently of the others, shall be so designed that when the incinerator is tested in accordance with the following requirements, any one igniter will effect ignition while the others are inactive. See Test Nos. 7 and 8.

56 Pilot Supervision – Test No. 7

56.1 Pilot supervision by a safety control shall be only at a point where the pilot flame will effectively ignite the fuel at the main burner or burner group with the pilot burning with any flame capable of actuating the primary safety control.

56.2 Test to determine conformance with the preceding paragraph is to be made in conjunction with the Combustion Test. Before a test is begun, the gas supply to the pilot is to be regulated to provide any flame which will actuate the primary safety control. At least five trials are to be made for each pilot flame tested.

56.3 The combustion detector of a primary safety control which is capable of detecting the presence of ignition spark shall be so positioned that the combustion detector shall respond to flame properties only. At the rated voltage, the signal strength due to an ignition spark shall be not more than 50 percent of the signal strength required to hold in the flame relay at 110 percent of rated voltage.

56.4 The test to determine conformance with the preceding paragraph is to be made in conjunction with the Combustion Test. Before a test is begun, the gas supply to the pilot is to be shut off. Five trials are to be made to determine that ignition spark, or reflection from any part of the burner or incinerator capable of reflecting the spark, will not result in a signal strength in excess of that specified throughout the entire trial-for-ignition period.

57 Ignition, Gas-Electric High Tension – Test No. 8

57.1 A gas-electric high tension ignition system, arranged for initially igniting a gas pilot, shall ignite the pilot upon admission of pilot gas in accordance with 57 – 57.5. The pilot, in turn, shall effect ignition of the main burner fuel as introduced into the ignition zone.

57.2 An electric high tension ignition system arranged for ignition of main burner gas directly shall effect the ignition when tested in accordance with 57.3 – 57.5. See also 58.1 – 58.3.

57.3 The burner assembly or incinerator, arranged and installed as for Test No. 1 is to be tested for conformance to the preceding paragraph after it has been subjected to the combustion test. The spark gap or gaps are to be adjusted to the maximum recommended by the manufacturer, but a gap is to be not less than 1/16 inch (1.6 mm).

57.4 The voltage of the power supply to the ignition system is to be regulated to 70 percent of rated voltage, and the voltage of the power supply to the safety control circuit is to be regulated to 85 percent of rated voltage for alternating current equipped and 80 percent of rated voltage for direct current incinerators.

57.5 The burner assembly or incinerator and ignition circuits are to be energized. Five trials are to be made. If the burner assembly or incinerator is to employ an interchangeable transformer, the appropriate interchangeable test transformer is to be applied to the burner assembly or incinerator and five additional trials for ignition are to be made. During each trial, ignition is to be effected safely and no flame is to flash outside the incinerator being fired.

58 Delayed Ignition – Test No. 9

58.1 For an incinerator that is arranged for ignition of the main burner gas directly by an electric igniter or on which the input of the pilot exceeds 400,000 Btu per hour, delay of the ignition shall not result in flashback of flame to the outside of the incinerator or any damage to the incinerator and the connected vent system when tested in accordance with 58.2 and 58.3.

58.2 The incinerator shall be arranged as specified in the Combustion Test, 51, except the power to the electric igniter is to be connected through a switching device so that energization can be delayed for a controlled period of time. The tests are to be conducted with both the control system and the igniter energized at the rated voltage.

58.3 Ignition of the main burner or the pilot, whichever is applicable, is to be delayed initially for 1 second from the time the gas valve is energized. The test is then to be repeated with the delay period successively increased by 1 second, up to the maximum flame establishing period of the primary safety control that is employed. The ignition of the main burner or the pilot shall be in accordance with 58.1 for each of the trials.

59 Temperature Control – Test No. 10

59.1 A temperature control shall function to reduce the risk of an incinerator, when tested as described herein, delivering combustion chamber and/or flue gases at temperatures in excess of that specified by the manufacturer.

59.2 The temperature control, if adjustable, is to be set to the maximum allowable setting. A modulating type operating control provided to regulate the fuel input between high and low fire values shall be bypassed to permit the incinerator to operate on high fire.

59.3 The incinerator is to be placed in operation and firing at maximum input continued until such time as the temperature control functions to cause firing of the burner to cease. For an automatic reset control, the

test is to be repeated at the discretion of the testing agency and the cutout temperatures are to be averaged to determine acceptance.

60 Temperature Tests

60.1 General

60.1.1 When an incinerator is tested in accordance with these requirements, no part shall attain a temperature sufficient to damage required corrosion protection, to adversely affect operation of safety controls, to impair the value of required thermal or electrical insulation, nor to cause creeping, distortion, sagging, or similar damage when such damage to the material or part may cause the incinerator to become unsafe for use. The temperature rises at specific points shall be not greater than those specified in Table 60.1 unless otherwise indicated.

60.1.2 The temperature of the chimney shall not exceed that for which it was designed during the conduct of this test. (See Section 18, Capacitors.)

Table 60.1
Maximum temperature rises

Item	Maximum rise above inlet-air temperature[a]			
	Column 1		Column 2	
	Degrees F	(Degrees C)	Degrees F	(Degrees C)
Surfaces of test enclosure, ceiling, walls, and the like	90	50	175	97
Surfaces of floor beneath and within 3 feet (0.91 m) of a incinerator to be classified for installation on combustible floors	90	50	175	97
Surface of incinerator in lieu of test structure – standard clearances	180	100	310	173
Surface of incinerator in lieu of test structure – increased clearances	280	156	490	272
Surfaces of incinerator at points of zero clearance to test structure or exterior surfaces, vent pipe excepted, of a portable or mobile heater	90	50	175	97
Aluminum alloys:	73	41	84	47
1100	330	183	430	239
3003	430	239	530	294
2014, 2017, 2024, 5052	530	294	630	350
Flame spreaders and combustion heads:				
Gray cast iron	930	517	930	517
Chrome alloy cast iron, 0.5 – 1.0 percent chrome, 0.2 – 0.5 percent nickel or copper	1230	683	1230	683
Ductile, nodular, cast iron	1230	683	1230	683
Types 501, 502 iron-chromium steels	1230	683	1230	683
Type 430 iron-chromium steel	1430	794	1430	794
Type 442 iron-chromium steel	1560	867	1560	867
Type 446 iron-chromium steel	1560	867	1560	867
Type 309 iron-chromium-nickel steel	1730	961	1730	961
Flue-gas baffles:				
Aluminum coated steel	1030	572	1030	572

Table 60.1 Continued on Next Page